MISSISSIPPIAN FORAMINIFERA

W. McKay

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UNIVERSITY OF ALBERTA

MISSISSIPPIAN FORAMINIFERA OF THE SOUTHERN CANADIAN ROCKIES, ALBERTA

A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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ABSTRACT

Five Mississippian foraminiferal zones have been recognized in the Canadian Rockies, and correlated to the United States Cordillera, Mississippi Valley type section and Eurasia.

The most important Foraminifera are the endothyrids; members found are Granuliferella, Granuliferelloides, Chernyshinella, Plectogyra and Endothyra. They are associated with the rarer non-endothyrids Spiroplectammina, Ammodiscus, Tournayella?, Brunsia, Archaediscus, Palaeotextularia, Permodiscus and Eostaffella.

Complete sections of Mississippian strata were measured and sampled from the Front Ranges at Banff and Jasper, and the Foothills at Moose Mountain; zonal indices have been established for each section.

The distribution and abundance of Foraminifera in relation to lithology are graphically portrayed.

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Samples from the Banff, Moose Mountain and Jasper areas were collected during the summers of 1957, 1959 and 1960 by Dr. R. Green of the Research Council. The Mount Rae, Mount Darrah, Crowsnest Ridge and Bighorn Creek samples were passed on to the writer by Dr. S. J. Nelson, who collected them under the auspices of British American Oil Company.

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MISSISSIPPIAN OUTCROP LOCALITIES SOUTHWESTERN ALBERTA

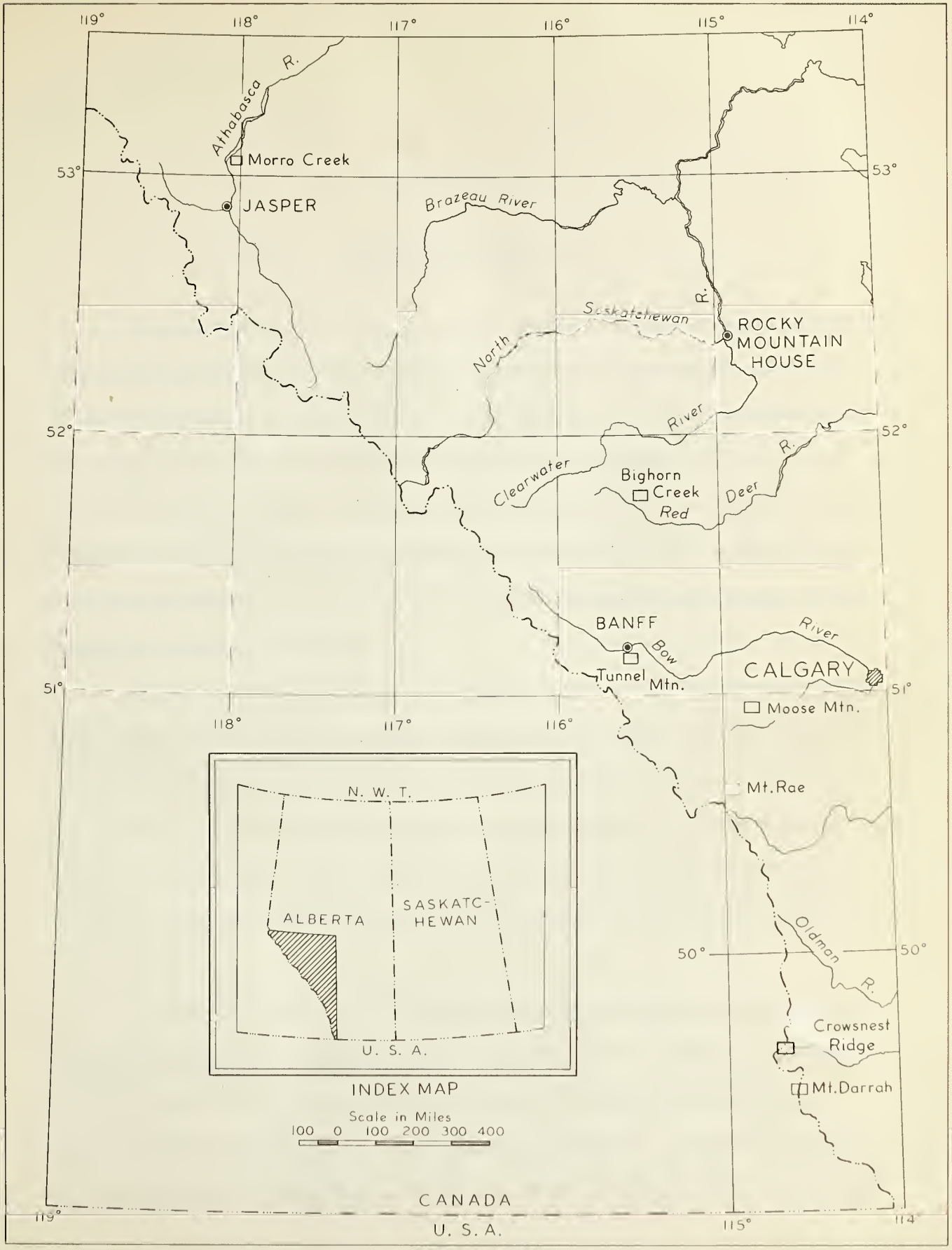

Figure 1

CHAPTER I

INTRODUCTION

During the past thirty-five years an increasingly large amount of palaeontological work has been carried out on Mississippian rocks in Western Canada. In spite of this, no detailed microfaunal studies have been published with the exception of Loranger's (1958) outline of subsurface Ostracod zones. In part, the present study is intended to remedy this deficiency, by examining endothyrid and related Foraminfera from selected stratigraphic sections in the Foothills and Front Ranges of the Rocky Mountains in Alberta.

After their appearance in the Late Devonian-Early Mississippian the Endothyridae developed rapidly into a large and diversified group. As individual species have limited vertical ranges and are widespread, the family has and is receiving extensive investigation in North America, Europe and Russia. With accumulation of literature from these areas, evidence shows that the evolutionary development of the family has been cosmopolitan.

Endothyrids of the Canadian Cordillera are Granuliferella, Granuliferelloides, Chernyshinella, Plectogyra and Endothyra. They are found with the rarer non-endothyrid genera Spiroplectammina, Ammodiscus, Tournayella?, Brunsia, Archaediscus, Palaeotextularia, Permodiscus and Eostaffella. Of these, only Granuliferella, Plectogyra,

Endothyra and Ammodiscus have been previously recorded from the North American Cordillera. The zonal significance of the non-endothyrids has yet to be established, but from limited study, they appear to have a restricted vertical distribution.

Knowledge of the North American endothyrids was greatly enhanced by the combined work of D. E. N. and E. J. Zeller (1953, 1950) who examined Mississippian rocks in the type region in the United States. Their investigations formed the groundwork for later studies including one on endothyrid faunas of the United States Cordillera (Zeller, 1957).

Zeller and Zeller (1950, 1953) found that the rocks of type area contained distinctive endothyrids of Kinderhookian, Osagean, Meremecian and Chesterian ages. These showed marked evolutionary changes, and although Zeller in 1957 was not able to correlate precisely between the Cordillera and type region, he found similar evolutionary trends. Armstrong (1958) and Woodland (1958) have made studies in the Cordillera since Zeller's initial work, and have verified Zeller's concept of the development pattern of the Endothyridae.

The present report extends these microfaunal studies into the southern Canadian Rockies, and is based on samples collected from Mississippian sections in the Front Ranges at Banff and Jasper, and in the Foothills at Moose Mountain. Supplementary information was yielded by samples from the University of Alberta. They are from sections on Bighorn Creek, Mount Rae, Mount Darrah, and Crowsnest Ridge (see Figure 1 for locations). A few Foraminifera were also obtained from cores of the Bear Beaumont and Shell Cadotte No. 1 Wells.

CHAPTER II

SAMPLING PROCEDURE AND GENERAL LITHOLOGY OF STRATIGRAPHIC SECTIONS

Relatively complete Mississippian sections were measured and sampled on Mount Rundle and Tunnel Mountain at Banff, on Canyon Creek in the Moose Mountain dome, and on Morro Creek at Jasper. In the first section, samples were systematically taken every five feet. In the other three sections, they were taken at approximately 20-foot intervals or at each visible change in lithology.

Mount Rundle and Tunnel Mountain

In the initial phase of this study the Banff and Rundle formations were systematically sampled at their type localities on Mount Rundle and Tunnel Mountain, respectively, near Banff, Alberta. The lithologies of both rock units have been described in detail by Beales (1950). For the sake of convenience some of his footages of the Rundle are included as a reference basis. (Figure 3)

At least one thin-section (1 to 1-1/2 inches by 2 inches) was made from rock slices cut perpendicular to the bedding plane in each sample, to determine whether Foraminifera were present. When found, additional thin-sections aided identification of all forms present. In some cases secondary dolomitization or silicification has destroyed all

fossil material, or at least has made it unidentifiable. Of 146 samples thin-sectioned from the Rundle at Banff, only 36 sections or 24 per cent contained Foraminifera.

The composite section at Banff includes 3715' of calcareous shales, limestones, and siltstones. In descending order, it is divided into the following formations:

Etherington formation - 255' - silty, dolomitic limestones and rare siltstones.

Mount Head formation - 480' cherty, dolomitic limestones.

"Livingstone" formation - 1480' - coarse, crinoidal limestones with dolomitized limestone intervals.

Banff formation - 1500' - calcareous shales to argillaceous cherty limestones.

As indicated on the population chart (Figure 3) most Foraminifera occur in the Mount Head and uppermost beds of the "Livingstone." Rare microfossils were observed at various horizons in the Etherington.

Canyon Creek - Moose Mountain

The rocks at Moose Mountain are part of a Palaeozoic inlier on the eastern edge of the Foothills. Because of this intermediate position they were considered valuable as an aid to correlating between the Plains and Front Ranges. Samples were collected from the east flank of the Moose Mountain dome from outcrops along Canyon Creek (Tp. 23, R. 7, W 5th) about 25 miles southwest of Calgary.

The Mississippian formations are in descending order:

Mount Head formation - 400' - cryptocrystalline dolomites with

associated anhydrites.

Turner Valley formation - 370' - crinoidal limestones in the lower part to dolomitic limestones and dolomites in the upper.

Shunda formation - 190' - lithographic limestones, dolomites.

Pekisko formation - 340' - crinoidal and oolitic limestones.

Banff formation - 510' - argillaceous cherty limestones to crinoidal limestones.

From both a mega- and microfaunal standpoint the Moose Mountain section is not fossiliferous. Although the crinoidal beds of the upper Banff formation were extensively thin-sectioned, no Foraminifera were found. A significant microfauna was noted only in the middle and upper Pekisko formation and lowermost Turner Valley formation. Of 62 samples thin-sectioned, Foraminfera were found in 10, or 16 per cent.

Morro Creek - Jasper

As a further aid to correlating between the Foothills and Front Ranges, Mississippian samples were collected at Morro Creek, Jasper. The section is essentially that of Brown (1952) but the lower part of his original Rundle formation has recently been placed in the Banff formation by Nelson and Rudy (1959) and assigned member names Shunda and Pekisko. Due to the questionable relationship between these Banff members and formations of the same name in the Foothills, they are referred to in quotations in this study. In descending order, the Morro Creek section is divided into the following units:

Rundle formation - 870' - mainly dolomitic limestones with rare oolitic and algal limestones in the lower part.

Banff formation -

"Shunda" member - 140' - oolitic, crinoidal limestones.

"Pekisko" member - 140' - coarse, crinoidal limestones.

Member B - 450' - argillaceous cherty limestones to coarse, crinoidal limestones in the upper part.

Member A - 180' - calcareous shales.

Major occurrences of the Foraminifera were found in the upper part of Member B, lowermost "Pekisko," "Shunda," and lower Rundle formation. Of 94 predominantly limestone samples thin-sectioned, Foraminifera were found in 21, or approximately 19 per cent. For obvious reasons, none of the dolomitized beds of the upper Rundle formation was thin-sectioned.

CHAPTER III

STRATIGRAPHY

Terminology used for Plains and Foothills rock units developed apart from that in the Mountains, as direct correlation is hindered by facies changes from east to west and by lack of palaeontologic control. Thus some discussion of the stratigraphic terms is necessary to enable fuller understanding of that used in this thesis. The reader is referred to a comprehensive history of the Mississippian terminology by Moore (1958).

Front Ranges

The Mississippian of the Front Ranges between Banff and Crowsnest Pass can be divided into two units; a lower recessive one represented by the Exshaw and Banff formations; and an upper dominantly resistant unit represented by the Rundle group (Livingstone, Mount Head and Etherington formations).

Type localities of the Banff formation and Rundle group are on Mount Rundle and Tunnel Mountain, respectively, at Banff, Alberta (Kindle, 1924; Beales, 1950). There, the Banff is divided into three unnamed lithologic units, and the Rundle into the Livingstone, Mount Head and Etherington formations. These formations have their type localities in the Mount Head area south of Banff. The type Livingstone

is divided into two members, an upper Turner Valley and lower Pekisko. Lithologic equivalents of this formation are found in the lower 1480' of the Rundle group at Banff. Temporal equivalents, however, of the Pekisko and lower part of the Turner Valley may be found in the upper Banff at Mount Rundle. Correlation of these units is hindered by the unfossiliferous nature of the beds.

The type Mount Head has six distinctive members: they are, in descending order, the Carnarvon, Marston, Loomis, Salter, Baril and Wileman. These members are equated to the lower and middle Mount Head and upper "Livingstone"* at Banff.

For discussion of the lithologic and temporal equivalents of the Etherington formation the reader is referred to Nelson (1961).

Plains and Foothills - Southern Alberta

Essentially the same two-fold division of Banff and Rundle is recognized in the Plains and Foothills; the Rundle is mainly dolomites, representing a more evaporitic phase of Mississippian sedimentation. The Plains formations are in ascending order the Banff, Pekisko, Shunda, Turner Valley and Mount Head.

Doubt exists as to where to draw the Banff-Rundle contact in parts where the Pekisko is present. From limited

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*When used in quotation, "Livingstone" refers to the formation at Tunnel Mountain, Banff.

microfaunal evidence, it appears that the Plains Pekisko equates to at least part of the upper type Banff. Moore (1958) considered the Plains Pekisko and overlying Shunda formations equal to the middle and upper Banff lithologic members, while Nelson and Rudy (1959) equated their "Pekisko" and "Shunda" to the upper Banff member only. Penner (1958, 1959), on the other hand, placed the Banff-Rundle contact between the Pekisko and Banff, restricting the latter to equivalents of the lower and middle members of type Banff. The suggested correlation of the Plains Pekisko and Shunda and Mountains Banff presented by this writer is in accordance with Nelson and Rudy's interpretation.

Front Ranges - Banff to Jasper

Brown (1952) made a comprehensive study of the Mississippian strata at Jasper, which he divided, in ascending order, into Banff, Rundle and Greenock formations, and pointed out from a faunal analysis, that the lower Rundle formation included considerable "Banffian" strata at the base. More recently, Nelson and Rudy (1959) have worked out the relationship between the Banff and Jasper Mississippian strata. On megafaunal and lithologic bases, they included the lower part of Brown's Rundle in the upper Banff, and proposed the member names "Pekisko" and "Shunda" for these strata. Rundle was retained for beds overlying the "Shunda" and underlying the Greenock formation. The middle and lower part of the Banff formation they designated as members B and A, respectively. This microfaunal study indicates that the Plains Pekisko is equivalent to the "Shunda" and probably the "Pekisko" at Jasper. No change of current terminology is proposed, however, until this correlation has been substantiated by further data.

CHAPTER IV

EVOLUTIONARY SEQUENCE OF THE ENDOTHYRIDAE IN WESTERN CANADA

This chapter is concerned with tracing the phylogenetic trends of the Endothyridae from the primitive granuliferellids to the much more highly developed Late Mississippian forms; and also with outlining the relationship of the granuliferellids to the earlier (Devonian) genus Nanicella.

Several significant gaps exist in present knowledge of the evolutionary sequence of the Endothyridae; these are a function of lack of fossil material from rocks of late Late Devonian and early and middle Kinderhookian, middle Osagean, and early Chesterian ages. These gaps exist in all complete sections so far studied in the Mississippi Valley and Cordillera. Discussion of the faunas thus falls into four sections, the divisions being gaps in the geologic record.

Early Late Devonian

Nanicella gallowayi (Thomas) is found in the upper Ireton formation of the Alberta Plains (Loranger, 1954). This planispirally and evolutely coiled septate species is characterized by a large number of chambers--16 to 17 in the outer volution. Due to the questionable nature of the wall structure and aperture, it is not considered an

endothyrid, although it is presumably ancestral to the latter septate group.

Early Mississippian (Late Kinderhookian and Early Osagean)

After their initial occurrence in the Early Mississippian (middle? or late Kinderhookian), the endothyrids developed rapidly; typical of this time were species of Granuliferella, Granuliferelloides, Chernyshinella, Plectogyra and rarely Endothyra.

The earliest endothyrid observed in Western Canada is Granuliferella tumida. This species, from the Alberta Plains, differs from the septate Devonian form in having plectogyroid coiling and fewer chambers (one third as many in the outer volution). From a thin-walled granuliferellid, such as G. tumida at least two lines of development can be traced; the main one being to Plectogyra, and a subsiduary one to the thick-walled Granuliferella granulosa and uncoiled Granuliferelloides. The relationship of the primitive chernyshinellids to granuliferellids is uncertain. The former may present a trend towards simplification of the coiling and increased asymmetry of the chambers, but on the other hand, may represent a separate line of development from the glomospirids.

Plectogyra spp. gained prominence in the early Mississippian following the reign of the thin-walled granuliferellids. This genus differs from Granuliferella mainly in having diagnostic secondary deposits and a differentiated wall. (This last feature represents a major advancement in the Endothyridae). Species of both Plectogyra and Endothyra are characterized by a wall composed of three layers. Identifications of this layering is often obscured by recrystallization but where observed, it consists of an inner dark layer (tectorium), a middle

light layer (diaphanotheca) and an outer dark layer (outer tectum). Secondary deposits laid down on the tectum form the outer tectorium (see Plate 10, Figure 14).

In the Canadian Rockies the earliest endothyrid, Plectogyra sp. aff. P. tumula, had features of both Granuliferella and Plectogyra. It has the large, inflated chambers of G. tumida, but in addition, the massive, secondary deposits of P. tumula. On the basis of the last feature, it is considered an early tumulate plectogyrid.

Species of Plectogyra with hook-shaped deposits developed from the tumulate plectogyrids. Plectogyra spinosa is an early representative of this line. Although the hook or hamulus is seen in later species of Plectogyra and Endothyra, there was a gradual trend toward its resorption in the early volutions, and in Meramecian species, it appears only in the last chamber.

Endothyra spp. were rare in the Early Mississippian as constancy of the coiling plane did not become an established feature until early Late Mississippian.

Middle Mississippian (Late Osagean and Meramecian)

The diverse fauna of granuliferellids, chernyshinellids, and tumulate and spinose plectogyrids was followed in late Early Mississippian by the small, thin-walled Plectogyra spp. (i.e. P. lanceolata).

There was a resurgence of the Endothyridae in the early Late Mississippian at which time Endothyra spp. became established, along with Plectogyra spp. Many evolutionary trends of these genera can be traced including changes in the coiling expansion rates, secondary deposits, sepatation and wall thicknesses.

In Endothyra the change in coiling pattern was one from even to uneven rates of expansion, with subsequent tightening of the initial coil. This change can be observed by comparing the respective early, middle and late Meramecian species, E. sp. A, E. zelleri, and E. macra E. J. Zeller. The last has a characteristic tightly coiled early portion. In species of Plectogyra the corresponding change in the expansion rates led to increased distortion of the coiling plane.

Two types of secondary deposits are found in the early Late Mississippian endothyrids: hook-shaped hamuli and septal additions. Single hamuli are characteristic of Meramecian endothyrids. In many species resorption of this deposit is complete except in the ultimate chamber, but in others, i.e., Plectogyra incrassata and Endothyra robusta, broad-based hamuli show incomplete resorption throughout the outer whorl. Secondary septal additions, a feature of late Meramecian species, was also observed in some late Early Mississippian species. The most extensive deposits are found in Plectogyra incrassata, P. sp. D and Endothyra robusta.

Changes in septation involved a shortening of the septa due to resorption. Evidence for this is found by comparing the long, thin septa of the early Meramecian Endothyra sp. A and short septa of the late Meramecian E. sp. D. This feature is also seen in the late Early Mississippian species, Plectogyra anteflexa.

Thick-walled Endothyra and Plectogyra species represent a line of development from early Meramecian species analagous to the Early Mississippian line of Granuliferella tumida to G. granulosa. These middle to late Meramecian species are among the largest endothyrids

found in North America, and are probably ancestral to the Pennsylvanian bradyinids.

Late Mississippian (Chesterian)

Small Plectogyra spp. were typical of the late early Chesterian, while larger species of this genus, characterized by prominent continuous layering on the chamber floor, dominated the middle-late Chesterian. Endothyra spp. were notably absent at this time, although late Chesterian Plectogyra spp. were reported by Raasch (1958), from the Canadian Cordillera, none were encountered in this study and Plectogyra kleina, a typical late early Chesterian species showing rudimentary secondary layering, represents the youngest described species.

CHAPTER V

MICROFAUNAL ZONES OF THE CANADIAN ROCKIES

Introduction

A number of Mississippian foraminiferal zones were recognized by Zeller (1957) in sections as far apart as Arizona, Utah and Montana. Subsequently Armstrong (1958) and Woodland (1958) recognized these zones in Utah and New Mexico.

Three of Zeller's zones have been outlined in the Canadian Cordillera; they are the Plectogyra tumula, Endothyra spiroides and Endothyra zelleri (E. symmetrica) zones. In addition, elements of Woodland's Plectogyra kleina zone and a new zone, Eostaffella, have been recognized. These zones are discussed in ascending order of occurrence as follows:

Plectogyra kleina zone

Eostaffella zone

Endothyra zelleri zone

Endothyra spiroides zone

Plectogyra tumula zone

In the United States Cordillera, the lowest zone is that of Granuliferella. Although granuliferellids are known from

the Lower Mississippian of Alberta, sampling has been insufficient to outline the zone.

Plectogyra tumula Zone

The Plectogyra tumula zone follows the Granuliferella zone where the latter is recognized. Elements of this zone occur at Morro Creek, Bighorn Creek, and Moose Mountain. At the first locality it extends from the upper part of Banff Member B to the lower part of the Rundle formation, and has a fauna characterized by Granuliferella granulosa, Granuliferelloides jasperensis, Spiroplectammina sp., Chernyshinella morroensis, Plectogyra tumula and P. sp. cf. P. spinosa.

At Bighorn Creek the zone was encountered in the lower Shunda formation, where it contained Granuliferelloides jasperensis, Chernyshinella sp., and P. tumula.

The upper part of the Pekisko formation at Moose Mountain has elements of the zone, including P. tumula and P. sp. cf. P. spinosa.

Above the Lower Mississippian Plectogyra tumula zone and below the Upper Mississippian Endothyra spiroides zone there is a fauna typified by Plectogyra lanceolata. Although recognized at several localities, the exact limits of this fauna are not known. It has been observed in the lowermost Turner Valley formation at Moose Mountain, the upper part of the Livingstone at Mount Darrah, and "Livingstone" at Tunnel Mountain (RG 57-1-87 to RG 57-1-76).

Endothyra spiroides Zone

Fauna of the Endothyra spiroides zone, occurring at several horizons in the upper "Livingstone" and lower Mount Head at Tunnel Mountain (RG 57-1-75 to RG 57-1-39), includes Endothyra sp. A, E. sp. B, a close-coiled Endothyra sp., Plectogyra sp. C, rare Plectogyra lanceolata, Tournayella? nonconstricta, Ammodiscus sp. A and rare Brunsia sp. Species of the upper part of the zone are closely related to ones of the overlying Endothyra zelleri zone.

Endothyra zelleri (E. symmetrica) Zone

This zone spans the middle part of the Mount Head formation (RG 57-1-38 to RG 57-1-30) at Tunnel Mountain, and has been recognized in the samples examined from 50' below the top of the same unit at Mount Rae. The fauna is diverse, and includes Endothyra zelleri, E. robusta, Plectogyra incrassata, Tournayella? nonconstricta, Ammodiscus sp. A, Archaediscus sp. and Brunsia sp.

Eostaffella Zone

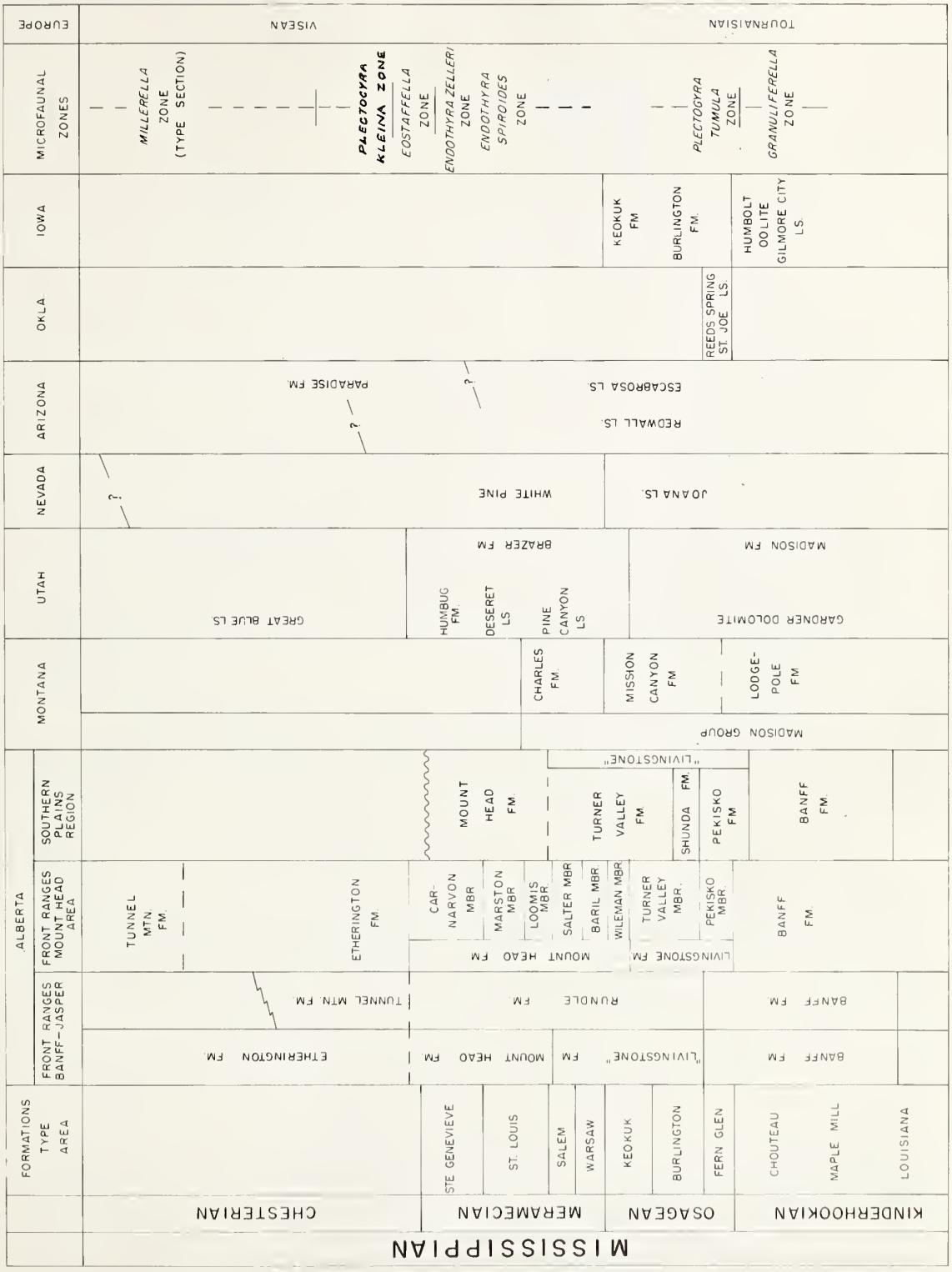
Fauna of this zone is found in the upper Mount Head formation (RG 57-1-29 to RG 57-1-18) at Tunnel Mountain. The lower part coincides with an endothyrid limestone containing approximately 60% Foraminifera; mainly endothyrids (RG 57-1-29). The upper limit of the zone is vague. This zonal fauna represents the most diverse encountered in the Canadian Rockies. Endothyra flatile, E. robusta, E. macra, E. sp. C, E. sp. D, Plectogyra sp. D and P. sp. E occur with

the non-endothyrids Tournayella? nonconstricta, Ammodiscus sp. A, Archaediscus sp., Brunsia sp. Palaeotextularia sp. and Permodiscus sp. The latter species was observed at only one horizon.

Plectogyra kleina Zone

Rare small plectogyrids including the index species have been observed in the lowermost beds of the Etherington formation at Tunnel Mountain. These forms represent the youngest identifiable endothyrid fauna of this study.

Figure 2


MISSISSIPPIAN
KINDERHOOKIAN
OSAGEAN
MERAMECIAN
CHESTERIAN
FORMATIONS TYPE AREA
LOUISIANA
MAPLE MILL
CHOUTEAU
FERN GLEN
BURLINGTON
KEOKUK
WARSAW
SALEM
ST. LOUIS
STE GENEVIEVE
ALBERTA
FRONT RANGES BANFF-JASPER
BANFF FM.
"LIVINGSTONE" FM.
MOUNT HEAD FM.
RUNDLE FM.
TUNNEL MTN. FM.
ETHERINGTON FM.
FRONT RANGES MOUNT HEAD AREA
BANFF FM.
PEKISKO MBR.
TURNER VALLEY MBR.
LIVINGSTONE FM.
WILEMAN MBR.
BARIL MBR.
SALTER MBR.
LOOMIS MBR.
MARSTON MBR.
CAR-NARVON MBR.
MOUNT HEAD FM.
ETHERINGTON FM.
TUNNEL MTN. FM.
SOUTHERN PLAINS REGION
BANFF FM.
PEKISKO FM.
SHUNDA FM.
"LIVINGSTONE"
TURNER VALLEY FM.
MOUNT HEAD FM.
MONTANA
LODGE-POLE FM.
MISSION CANYON FM.
CHARLES FM.
MADISON GROUP
UTAH
MADISON FM.
GARDNER DOLOMITE
PINE CANYON LS.
DESERET LS.
HUMBUG FM.
BRAZER FM.
GREAT BLUE LS.
NEVADA
JOANA LS.
WHITE PINE
ARIZONA
REDWALL LS.
ESCABROSA LS.
PARADISE FM.
OKLA.
REEDS SPRING
ST. JOE LS.
IOWA
KEOKUK FM.
BURLINGTON FM.
HUMBOLT OOLITE
GILMORE CITY LS.
MICROFAUNAL ZONES
GRANULIFERELLA ZONE
PLECTOGYRA TUMULA ZONE
ENDOTHYRA SPIROIDES ZONE
ENDOTHYRA ZELLERI ZONE
EOSTAFFELLA ZONE
PLECTOGYRA KLEINA ZONE
MILLERELLA ZONE (TYPE SECTION)
EUROPE
TOURNAISIAN
VISEAN

CHAPTER VI

CORRELATION OF ENDOTHYRID ZONES IN THE NORTH AMERICAN CORDILLERA

Mississippian Endothyridae of the United States Cordillera have been studied by Zeller (1957), Armstrong (1958), and Woodland (1958). Woodland's Utah section is the most complete in that it contains both Lower and Upper Mississippian endothyrids. In all other Cordilleran sections, only Foraminifera of Lower or Upper Mississippian are represented.

The lower part of Woodland's section--the upper Gardner limestone--contains the Lower Mississippian Granuliferella zone and Plectogyra tumula sub-zone. Intermediate between this lower zone and the Upper Mississippian Endothyra zelleri (E. symmetrica) zone, and isolated by unfossiliferous intervals, is a faunal horizon containing Plectogyra lanceolata. This fauna is referred to herein as the Pine Canyon fauna because of its occurrence in that formation. Above the Endothyra zelleri zone, Woodland recognized the younger sparsely fossiliferous Plectogyra kleina zone.

The Granuliferella zone was first outlined by Zeller (1957) in the Madison limestone of Utah and Wyoming and the

Joana limestone of Utah. As previously noted this zone has not been outlined in Alberta.

Zeller (ibid) found the Plectogyra tumula zone at several localities in the United States Cordillera, including Montana, where it spans the upper 100-200' of the Lodgepole formation and lower 300-400' of the Mission Canyon formation. In Wyoming and Utah, it occurs in the respective intervals 200-700' and 500-1000' above the base of the Madison formation.

At Morro Creek, Jasper, Alberta, the Plectogyra tumula zone extends from the upper part of the Banff member B to the lower part of the Rundle formation (approximately 600-900' above the base of the Banff formation). The fauna of the lower and middle part of the zone at this locality is similar to that depicted by Woodland (1958) from the upper Gardner limestone. At Moose Mountain, this zone spans the middle and upper Pekisko formation. At both Alberta localities the upper part of the zone is characterized by a spinose plectotyrid which has also been observed in the upper part of the same zone in Wyoming.

The Pine Canyon fauna of Utah, representing the only intermediate one between the Lower and Upper Mississippian zones, consists of Plectogyra lanceolata and P. turgida. The former is found in the lowermost beds of the Turner Valley formation at Moose Mountain, and the upper part of the "Livingstone" at Tunnel Mountain where it is associated

with a fauna of definite Meramecian affinities.

The Endothyra spiroides zones immediately follows the Plectogyra lanceolata interval in the Front Ranges at Tunnel Mountain. The E. spiroides zone is recognized in Utah and Nevada where it encompasses strata 400-700' above the base of the Redwall formation. Elsewhere in Utah it spans the interval 2000-2600' above the base of the Brazer limestone, and the interval 100-150' above the base of the White Pine formation.

In the United States Cordillera, Zeller (1957) observed the Endothyra zelleri (Endothyra symmetrica) zone in the upper Brazer formation of Utah, and Redwall limestone of Nevada immediately above the Endothyra spiroides zone. It also occurs through a 200 interval 600' above the base of the Escabrosa limestone in Arizona. Woodland (1958) outlined the zone in the upper Deseret and lower Humbug of Utah.

The Endothyra zelleri zone occurs above the Endothyra spiroides zone at Tunnel Mountain, extending through the middle Mount Head formation. It was also recognized in strata 40-50' below the top of the same formation at Mount Rae.

The Eostaffella zone follows the E. zelleri zone in the Tunnel Mountain section. Most species of the former zone are closely related to those of the underlying one, but the new

elements have no correlatives in North America.

Beds of Chesterian age at Tunnel Mountain are virtually devoid of Foraminifera, however, rare specimens of Plectogyra kleina are known from the lower part of the Etherington formation. The P. kleina zone has been recognized in the lower Great Blue limestone of Utah (Woodland, 1958).

CHAPTER VII

CORRELATION TO THE MISSISSIPPI VALLEY

In the Mississippi Valley the endothyrid faunas of Kinderhookian to Chesterian age can be readily differentiated from each other, for each stage has characteristic species.

The earliest representatives of the family in the type section are Plectogyra spp., which were observed in the upper Kinderhookian Chouteau equivalents, (Gilmore City limestone and Humbolt oolite). Plectogyra spp. also occur in the lower Osagean St. Joe and upper Osagean Keokuk formations, but they are notably smaller and thinner-walled than the Kinderhookian species.

The relationships between the Upper Mississippian endothyrids of the Salem, St. Louis and Ste. Genevieve formations is very close and only minor variations in secondary deposits and coiling occur (Zeller ibid.) Both Plectogyra and Endothyra are found, but no specific names were attached except to the genotype, Plectogyra plectogyra E. J. Zeller.

Both the Meramecian and Chesterian formations have abundant microfauna. In the latter, many species of Plectogyra and Millerella are found, but it is noted that Endothyra is unique to the Meramecian.

Species of Osagean, Meramecian and Chesterian ages are similar to species in the Cordillera, but there appears to be little to no

similarity between the Kinderhookian and early Osagean faunas of the two areas.

The only correlatives of the Granuliferella zonal fauna in the Mississippi Valley are rare thick-walled forms from the Humbolt oolite (Zeller, 1950) which are comparable with Granuliferella granulosa. It is interesting to note that Zeller (1957) and Gutschick (1960) considered the fauna of the Granuliferella zone to be late Kinderhookian, while Woodland (1958) gave it an Osagean age. Due to Kinderhookian faunal affinities of the younger Plectogyra tumula zone, the present writer would assign a Kinderhookian age to the Granuliferella fauna.

The Plectogyra tumula zonal fauna, characterized by well-developed diagnostic secondary deposits, was not encountered in the type section. It is noteworthy that in size and number of volutions, the fauna of this Cordillera zone is more closely related to type Kinderhookian than Osagean. On this basis, it is considered either late Kinderhookian or early Osagean.

Plectogyra lanceolata is similar to the small plectogyrid species from the St. Joe limestone (Zeller, 1950, Plate 2, Figures 9-13). At some intervals in the Cordilleran strata, P. lanceolata is associated with Endothyra spp. showing definite Meramecian affinities, whereas, the St. Joe fauna is considered early Osagean. Thus the age relationship of this species is at present somewhat anomalous.

Species of Plectogyra and Endothyra from the Cordilleran Endothyra spiroides zone and type section Salem limestone have many features in common. For example, two Endothyra species were observed in the Salem: one loose- and one close-coiled. This is noteworthy as both coiling types were found in the E. spiroides zone. A great deal of similarity also exists between the large plectogyrid of the Salem (Zeller, 1950, Plate 3, Figure 13) and Plectogyra sp. C.

The fauna of the overlying Endothyra zelleri zone shows affinities to the St. Louis and Ste. Genevieve faunas; however, the thick-walled Endothyra robusta has no correlative in the type section.

None of the elements of the Eostaffella zone have been observed in the Mississippi Valley. On the basis of the age of the overlying Plectogyra kleina, this fauna is considered late Meramecian or early Chesterian.

Plectogyra kleina, the youngest identifiable species of this study, is similar to the small late early Chesterian plectogyrids of type section (Zeller, 1950, Plate 5, Figures 20, 21).

CHAPTER VIII

DISSERTATION ON ASIATIC AND EUROPEAN FAUNAS

The earliest endothyrids reported from Asia are the Late Famennian Endothyra communis Rauser-Cernoussova and Quasiendothyra sp. These forms, characterized by strong chomata and evolute coiling, attained optimum development in Late Famennian but continued through to Late Tournaisian. They were associated with primitive plectogyrids, tubular Foraminifera and tournayellids in their early history. The Late Devonian septate Nanicella gallowayi is similar to the Asiatic Quasiendothyra in being evolute and planispirally coiled, but lacks chomata.

In the Middle and Late Tournaisian, there was a more diverse fauna; species of Brunsiina, Tournayella, Spiroplectammina, Ammodiscus and Chernyshinella were associated with tuberculate and spinose Plectogyra.

In North America the closest comparable fauna of the Tournaisian is found in the Morro Creek section, Jasper. There, species of Spiroplectammina, Chernyshinella and Tournayella? occur with tumulate and spinose plectogyrids and rare evolutely coiled planispirals.

In Europe there is less detailed information on the Tournaisian Foraminifera. D. E. N. Zeller (1956) described

a species of Plectogyra from the Lower Tournaisian K zone of the English Carboniferous that is comparable to P. tumula of North America. Recently Cummings (1960, in George) identified an Upper Tournaisian microfauna from the English C1 zone, including Tournayella, Brunsiina, Chernyshinella and Plectogyra. Of these Chernyshinella and Plectogyra are typical of the Lower Mississippian in the Canadian Cordillera.

The Visean rocks of the Russian platform have a well-developed microfauna, including the primitive fusulinid genera Eostaffella and Parastaffella, and thick-walled endothyrids. As well as members of the Endothyridae and Fusulinidae, other typical Lower to Middle Visean Foraminifera are Archaediscus (an important Early Visean genus), Forshiella, Lituotubella, Palaeotextularia, Climacammina, Cribrostomum, and Permodiscus. The Lower to Middle Visean assemblage depicted by Zeller (1956) is similar to that of the Russian platform. It can be seen that this Eurasian assemblage is not the same as that found in the lower Upper Mississippian of North America in that it presents a more advanced stage in the evolutionary development of the Endothyridae and other microfauna. Studies made in the Kuznetsk basin in south-central Asiatic Russia (Reitlinger, 1958) reveal a fauna similar to that of Late Osagean-Meramecian of this continent. The Kuznetsk fauna is underlain and overlain by characteristic Eurasian Tournaisian and Visean assemblages respectively.

Reitlinger described the fauna as being neither typically Tournaisian nor Visean, but instead consisting of--"flat spiral forms with slight variation of the axis of coiling of the type of 'true' Endothyra[1] but at the same time having in the last chamber hamuli--there also develop peculiar flat-spiral forms with pseudo-chomata, on the one hand reminding one of Endothyra crassa, on the other hand of the parastaffellids--there is also a prevalence of forms with a high spiral[2]--".

The impression gained by the present writer from Reitlinger's description is that a number of forms resemble species of Endothyra and Plectogyra of the Meramecian and Osagean strata of North America. The hamulus-bearing Endothyra are reminiscent of such species as E. zelleri, and closely related Endothyra of the Meramecian; the thick-walled group, similar to E. crassus, suggests a relationship to Endothyra robusta.

The Lower Visean fauna of the Russian platform represents one younger than that found in the lower Upper Mississippian of this continent, and it is noteworthy, therefore, that an Upper Tournaisian-Lower Visean fauna has been recognized in central Asia, that is similar to that of the Upper Osagean and Meramecian of North America.

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1. By 'true' Endothyra, Reitlinger means those forms that are planispirally coiled and lacking of diagnostic secondary deposits.

2. These forms are typical of the North American Osagean.

CHAPTER IX

CORRELATION OF MISSISSIPPIAN FORAMINIFERAL AND MEGAFAUNAL ZONES OF THE CANADIAN ROCKIES, ALBERTA

The Mississippian megafaunal zones of the Rockies are based mainly on brachiopods and corals. Studies have been carried out by Laudon (1943), Brown (1952), Raasch (1958), Harker and Raasch (1958), and more recently by Nelson (1958, 1959a, 1959b, 1960 and 1961).

Correlation of the foraminiferal and megafaunal zones at Morro Creek and Tunnel Mountain are discussed, but because of the questionable identification of the megafauna, the Moose Mountain section is not dealt with here.

Morro Creek, Jasper

Brown (1952) recognized three zones at Morro Creek which span the Banff formation (Brown's Banff and lower Rundle). These zones are in ascending order the Spirifer sp. cf. cascadensis, S. albertensis and Composita esplanadensis. The latter zone is virtually unfossiliferous, the megafauna being confined to a horizon in the upper "Shunda".

In age, the fauna of the two lower zones is Kinderhookian, and the upper, Osagean (Brown, 1952; Nelson, 1961). The Plectogyra tumula faunal zone, with which the upper

Composita esplanadensis zone coincides, is considered early Osagean in age also.

Tunnel Mountain, Banff

Nelson (1958, 1959, 1960 and 1961) outlined many megafaunal zones in the Rundle group of the Front Ranges, however, only those recognized at Tunnel Mountain are discussed.

Corresponding to the "Livingstone", the lowest formation this study is concerned with, are three zones: the lower Spirifer banffensis, middle unnamed, and upper Lithostrotion sinuosum. The last-mentioned coincides approximately with the Endothyra spiroides zone. It is noted that although Nelson considered fauna of the L. sinuosum zone to be late Osagean, the Foraminifera are more likely early Meramecian in age.

Zones spanning the Mount Head formation are in ascending order: Echinoconchus biseriatus, Girtyella indianensis, and Gigantoproductus brazerianus. The E. biseriatus zone coincides with part of the Endothyra spiroides zone, the E. zelleri zone, and part of the Eostaffella zone. The upper part of the Eostaffella zone can probably be equated with the Girtyella indianensis zone and part of the Gigantoproductus brazerianus zone. Both the megafauna and Endothyridae are considered Meramecian in age.

It is interesting to note that Nelson observed the G. brazerianus zone at the Mount Head-Etherington contact in the Mount Rae section south of the Banff area, and approx-

imately 100' below the top of the Mount Head formation at Tunnel Mountain. The Endothyridae of the two areas bear much the same stratigraphic relationship. Elements of the Endothyra zelleri zone found at Mount Rae and observed in strata 40-50' below the top of the unit equate with fauna 200' below the top of the Mount Head formation at Tunnel Mountain.

Three zones span strata approximating the Etherington formation; they are the Dictyoclostus parvus, Punctospirifer transversa, and Diaphragmus elegans zones, the fauna of which is considered Chesterian (Nelson, 1961). Plectogyra kleina, found in the lower part of the same formation, is a typical early Chesterian form; thus the Foraminifera and megafauna of this part of the section approximate each other in age.

CHAPTER X

ECOLOGY AND LITHOLOGIC DISTRIBUTION

Endothyridae and related Foraminifera are found associated with crinoids, corals, brachiopods, bryozoan, molluscs, gastropods, ostracods and algae in limestones reflecting shallow water.

Edie (1958) in relating the lithology and depositional environments of Plains Mississippian, noted marked facies changes in the Lodgepole, Mission Canyon and Charles formations of southeastern Alberta and southern Saskatchewan. Each facies--basin, open marine shelf, barrier bank and lagoonal--had a characteristic faunal assemblage. Illing (1959) found the same cycles in the Moose Mountain section of the Foothills.

Sediments laid down in the basin facies are calcareous shales and argillaceous limestones with a fauna of crinoid ossicles, sponge spicules, ostracods, and brachiopods. This lithology is typical of the Banff and Lodgepole formations and is notably lacking in Foraminifera.

The open marine shelf environment, characterized by fossiliferous, fragmental limestones with a fauna of crinoids,

bryozoan, brachiopods and corals, is typical of much of the "Livingstone" formation at Tunnel Mountain. In these limestones, Foraminifera are sparse.

Edie (ibid) noted that the oolitic, pelletoidal and lithographic limestones of the barrier bank had abundant associated endothyrids. The limestones of the upper Turner Valley and lower Mount Head formation, the upper Pekisko at Moose Mountain, and part of the "Shunda" and lower Rundle formation at Jasper are of this type of lithology.

The lagoonal phase is represented by the unfossiliferous dark, algal, pelleted limestones of the Shunda formation at Moose Mountain, and part of the lower Rundle at Jasper. Foraminifera are absent in this type of lithology as well as the closely related anhydrites, sucrosic dolomites and chalky limestones of the restricted phase.

Detailed lithologies of pertinent portions of the sections at Tunnel Mountain, Moose Mountain, and Morro Creek are shown in Figures 3 and 4.

CHAPTER XI

CONCLUSIONS

Endothyridae, because of their rapid evolutionary changes and world-wide distribution, appear to be useful zonal fossils. The related Foraminifera are restricted to certain intervals in the stratigraphic column, and should also prove of correlative value.

Five foraminiferal zones have been recognized in the Canadian Cordillera; they are in ascending order Plectogyra tumula, Endothyra spiroides, E. zelleri, Eostaffella and Plectogyra kleina. Elements of the Granuliferella zone were observed, but at present there is insufficient data to outline it.

The Granuliferella zone is the earliest endothyrid zone in North America. It is known in Utah and Wyoming, where it is succeeded by the Plectogyra tumula zone. This latter zone is widespread in the Cordilleran region occuring in Utah, Wyoming, Montana and southern Alberta. The endothyrid fauna of the zone is considered late Kinderhookian or early Osagean in age.

Throughout the Cordillera there is a gap in the foraminiferal record above the Plectogyra tumula zone. Follow-

ing this gap is the foraminiferal assemblage which has been referred to herein as the Plectogyra lanceolata fauna of Alberta, and the Pine Canyon fauna of central Utah. In Alberta, the fauna is known from the Foothills and Front Ranges, but only at Tunnel Mountain has a significent interval been observed. Endothyra spp. associated with P. lanceolata at the latter locality indicate a late Osagean or early Meramecian age for the fauna.

The Endothyra spiroides zone, recognized at Tunnel Mountain, has a fauna with Meramecian Salem affinities. It is followed by the E. zelleri zone, the fauna of which has been broadly correlated to that of the St. Louis and Ste. Genevieve formations.

The newly established Eostaffella zone, occuring in the Canadian Rockies, has a fauna considered to be very late Meramecian. This is based on the close relation of the species to those of the underlying Endothyra zelleri zone, as well as the early Chesterian age of the overlying Plectogyra kleina fauna.

Rare Foraminifera have been observed in Chesterian strata of the Canadian Cordillera. Plectogyra kleina, found also in the lower Great Blue limestone of Utah, was recognized at one horizon at Tunnel Mountain in the lower Etherington formation. This early Chesterian form represents the youngest identifiable species of the present study, although recognizable late Chesterian species

have been reported from the upper part of the Rundle group south of the Banff area.

In comparing the foraminiferal suites of Eurasia and North America, it has been noted that several Lower Tournaisian and Lower Mississippian species are comparable, whereas, there is a striking difference between the Lower Visean and Upper Mississippian assemblages. Studies recently made in the Kuznetsk basin of Central Asia revealed Upper Tournaisian-Lower Visean endothyrid species which have a suggested relationship to North American Mississippian species.

Of particular importance in this study has been the recognition of the Plectogyra tumula zone in the Foothills and Front Ranges. From limited evidence, it appears that the fauna of the upper part of the zone at Moose Mountain and Morro Creek are close in age. At the former locality the zone spans the middle and upper Pekisko formation, and at the latter, the "Pekisko", "Shunda" and lower Rundle. There are significant breaks in the foraminiferal record in both sections that hinder definite correlation, however, with further outlining of the P. tumula zone in the intervening area a more precise relationship should be establishable.

CHAPTER XII

FORMAL DESCRIPTIONS

Phylum PROTOZOA

Class SARCODINA

Order FORAMINIFERA

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

Ammodiscus sp. A

Plate 6, Figure 10; Plate 7, Figure 9

Test discoidal, evolute, planispirally coiled; diameter of initial spherical chamber 0.06 mm., followed by a second undivided chamber showing uniform expansion rate; average diameter 0.50 mm.; wall finely granular, calcareous, increasing uniformly in thickness from inner to outer portion; aperture formed by the open end of the tubular chamber.

Locality of figured specimens: PF 0004 (RG 57-1-66), PF 0040 (RG 57-1-32), Tunnel Mountain, Alberta, from the upper part of the "Livingstone" formation and middle part of the Mount Head formation respectively.

Occurrence: This species is found at several intervals in the uppermost "Livingstone" formation and Mount Head formation at Tunnel Mountain.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus BRUNSIA Mikhailov, (1935) 1939

This is a typical Asiatic genus which has not previously been reported from North America. It differs from Glomospira by showing more regularity of the coiling plane, and from Ammodiscus by not being completely planispirally coiled.

Brunsia sp.

Plate 7, Figures 2, 6; Plate 11, Figure 13.

Test minute, discoidal, evolute; plane of coiling irregular in the initial portion, becoming more or less constant in the outer whorls; initial chamber spherical, followed by a tubular, undivided chamber; average diameter, 0.30 mm.; whorls 5 to 6; wall finely granular, calcareous; aperture formed by the open end of the tubular chamber.

Locality of figured specimens: PF 0005 (RG 57-1-33), PF 0006 (RG 57-1-32). Tunnel Mountain, Alberta, from the middle beds of the Mount Head formation; PF 0007 (MR 34-477), Mount Rae, Alberta, from 50' below the top of the Mount Head formation.

Occurrence: At Tunnel Mountain Brunsia sp. is most common in the middle Mount Head formation, but occurs also in the upper part, and

at Mount Rae is known from the interval 40-50' below the top of the formation.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family ARCHAEDISCIDAE

Genus ARCHAEDISCUS H. B. Brady, 1873

Archaediscus sp.

Plate 7, Figures 1, 3; Plate 11, Figures 5, 11

Test small, rectangular, periphery broadly rounded, sides almost parallel; initial chamber spheroidal, followed by a second tubular chamber coiled in more than one plane; height 0.19 to 0.28 mm., width 0.08 to 0.09 mm.; 5 whorls, wall of inner whorls extending to the centre, outer whorl evolute; in axial section chamber lumina appearing semi-elliptical; wall composed of an outer radial hyaline layer and an inner dark, finely granular layer approximately 1/6 the thickness of the outer part; aperture formed by the open end of tubular chamber.

Locality of figured specimens: PF 0015, PF 0016 (RG 57-1-33), Tunnel Mountain, Alberta, from the middle Mount Head formation; PF 0017, PF 0014 (MR 34-477), Mount Rae, Alberta, from 50' below the top of the same unit.

Occurrence: This species is rarely represented in the Mississippian of the Canadian Rockies. At Tunnel Mountain

it occurs through the middle and upper beds of the Mount Head formation, and at Mount Rae, in the interval examined 50' below the top of the same formation.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus PERMODISCUS Chernysheva, 1948

This genus is differentiated from Archaediscus on the basis of the planispiral coiling.

Permodiscus sp.

Plate 10, Figure 5

Test minute, discoidal, symmetrical, periphery broadly rounded, coiling in a single plane; diameter 0.15 mm., width 0.075 mm.; diameter of initial chamber 0.035 mm.; chamber lumina appearing semi-elliptical in axial section; walls of each whorl extending to the centre; wall composed of an outer radial hyaline layer and a dark finely granular layer approximately 1/6 the thickness of outer layer; aperture formed by the open end of the tubular chamber.

Locality of figured specimen: PF 0018 (RG 57-1-18), Tunnel Mountain, Alberta, from the upper beds of the Mount Head formation.

Remarks: In size Permodiscus sp. resembles P. rotundus Chernysheva from the Visean rocks of the Russian platform, but

has a larger spherical initial chamber and fewer volutions than the latter.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family TOURNAYELLIDAE

The Tournayellidae are a group of pseudo-septate glomospirally to planispirally coiled forms; the glomospiral members are considered ancestral. Although the latter developed in Famennian time, the main development of the group was through the Tournaisian, with the peak of development in the upper part of the stage. The family is closely related to both Ammodiscidae and Endothyridae, and in recent publications has been referred to either family.

In species of Tournayella there is an early non-septate portion which shows slight angulation, and an outer portion with pronounced infolding of the wall. Further infolding leads to the formation of true septa, as seen in species of the later genus Septatournayella.

Genus TOURNAYELLA Dain, 1953

Tournayella? nonconstricta, n. sp.

Plate 7, Figures 4, 5; Plate 8, Figure 3; Plate 11, Figure 4

Test discoidal, evolute, umbilicate, periphery rounded; coiling planispiral showing slight irregularity of the plane in the outer volutions; initial chamber spherical, followed

by a tubular chamber with constrictions of the wall, true septa rarely developed, angulation of the wall barely perceptible in the early portion, becoming pronounced in the outer; diameter 0.80 mm. to 1.60 mm.; volutions 5 to 7; secondary deposits consisting of irregular layering on the chamber floor, and a hook rarely present in the terminal portion behind the aperture; wall finely granular, calcareous, with large inclusions; aperture unconstricted, formed by the open end of the tubular chamber.

The name of this species is derived from the nature of the aperture which is unconstricted.

Holotype: (Plate 7, Figure 5), PF 0008, diameter 0.84 mm.

Paratypes: (Plate 7, Figure 4; Plate 8, Figure 3; Plate 11, Figure 4),
PF 0009, diameter 1.20 mm.
PF 0010, diameter 0.94 mm.
PF 0011, diameter 1.34 mm.

Locality of holotype and paratypes: PF 0008, PF 0009, PF 0010 (RG 57-1-30), Tunnel Mountain, Alberta from the middle part of the Mount Head formation; PF 0011 (MR 34-974), Mount Rae, Alberta, from 50' below the top of the same formation.

Occurrence: Tournayella? nonconstricta is common in the Mount Head formation at Tunnel Mountain, and the upper part of the same formation at Mount Rae.

Remarks: No tournayellids have previously been reported from North America. The above-described species differs from the genotype (Dain, in Pokorny, 1958) in having more pronounced septation, more regularity of coil, and an open, unconstricted aperture. The degree of septation appears uniform in all specimens.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

Spiroplectammina as originally described by Cushman is, in composition, arenaceous, with a variable amount of cement. The arenaceous type is known from the Pennsylvanian to Recent.

The relationship of the early to late Carboniferous spiroplectamminids is not known. Cummings (1956) quoted Reitlinger as saying that Carboniferous species of the genus bear a remarkable similarity of form to representatives of Biseriammina, and that the common Upper Palaeozoic Spiroplectammina are their derivatives. On the other hand, Cushman (1928) suggested that Spiroplectammina is ancestral to the Carboniferous textulariids.

In the Russian literature, Tournaisian species are described as being typically finely granular and calcareous. The practice of placing a calcareous form in the genus Spiroplectammina is followed in this work, because of lack of knowledge.

Spiroplectammina sp.

Plate 1, Figures 7, 13; Plate 2, Figure 6

Test elongate, composed of an initial spirally coiled portion and a rectilinear biserial terminal portion. Spiral portion: one volution with a large proloculus followed by 4 to 5 chambers of similar size; average diameter (measured in 4 specimens), 0.22 mm.; septa and wall approximately the same thickness. Biserial portion: chambers 5 to 8 in each row; septa long, slightly curved, extending beyond the median line of test; linear portion increasing in diameter uniformly and gradually; average length 0.67 to 0.86 mm.; wall coarsely granular, calcareous; aperture simple, slit-like at base of apertural face.

Locality of figured specimens: PF 0019, 20 (RG 60-1-34), Morro Creek, Alberta, from the upper part of the Banff member A; PF 0021 (RG 60-1-37) from the lowermost bed of the "Pekisko" member.

Occurrence: Spiroplectammina sp. is known only from the two horizons of the Banff formation at Morro Creek.

Remarks: In most specimens the spiral portion is poorly preserved or absent. Of the described Palaeozoic forms, Spiroplectammina sp. most closely resembles S. tchernyshinensis Lipina from the Upper Tournaisian of the Russian platform. The latter has a calcareous wall, 6 to 7 chambers in the linear portion and an average length of 0.80 mm.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family ENDOTHYRIDAE

Genus ENDOTHYRA Phillips, 1843

Endothyra bowmanni Phillips. Brown, 1843, The Elements of Fossil Conchology, page 17, Plate 6, Figure 2.

(Non) Endothyra bowmani Phillips, 1846, Geol. and Polytech. Soc. West Riding Yorkshire, Proc. 1844-45, Vol. 2, page 277, Plate 7, Figure 1.

The name Endothyra has been the subject of controversy since its introduction in the last century. Two palaeontologists, Brown (1843) and Phillips (1846) described a microfossil called Endothyra from the Lower Carboniferous limestone of England, but each outlined a different species. Brown's figure was that of a planispiral form with 4 whorls, and up to 19 chambers in the outer whorl. He called it Endothyra bowmanni Phillips indicating that he considered Phillips the author. Phillips' form, on the other hand, is that of a "skew-coiled" form with 2 whorls, and 8 chambers in the outer whorl. Illustrations of these two species can be found in Henbest (1953) and St. Jean (1957).

In 1876 Brady formally revised the genus. He redescribed and refigured Phillips' original specimen, showing that it represented a form coiled in more than one plane. In a subsequent publication, however, Brady (ref. Zeller, 1950) decided that Brown should be credited as the true author of Endothyra according to the International Rules of Zoological Nomenclature.

The planispirally coiled species that Brown (1843) described, and here considered to be the genotype of Endothyra has not been encountered in the Mississippian of this continent. However, D. E. N. Zeller (1956) in her study of the English Lower Carboniferous microfauna illustrated several Endothyra specimens similar to those described by Brown.

There is disagreement among present authors over the placing of planispirally- and skew-coiled species in one genus. Scott, Zeller and Zeller (1947) examined the microfauna of the Salem limestone (Indiana), a well-known oolitic limestone with abundant endothyrids. All the forms examined showed a remarkable uniformity in test size, shape and coiling. They further indicated that the coiling in the specimens was not random but was a "three dimensional figure produced by a point moving in a plane so as to generate a logarithmic spiral while the plane is simultaneously rotated about an axis passing through the centre of the spiral." For species similar to Endothyra baileyi Hall, Zeller (1950) later erected the new genus Plectogyra, with genotype Plectogyra plectogyra, and defined it to include any form that showed the tendency to be coiled in more than one plane.

Henbest (1953) and Pokorny (1958) have contested the validity (or need) for this new genus, and suggest that the two types of coiling represent only the megalospheric and microspheric forms of a single species.

A critical revision of the name Plectogyra was given by St. Jean (1957). He suggested that Brown had erred in assigning his form to Endothyra, and that instead it represented a member of the

fusulinids. He considered that Phillips' form (which was later redefined by Brady) should be the true Endothyra. The fact that D. E. N. Zeller (1956) identified Endothyra spp. similar to Brown's figured specimen leads the present writer to conclude that the latter's form was a true Endothyra, and there is justification for the erection of the new genus Plectogyra.

Reitlinger (1958) included the name Plectogyra in his descriptions of the Endothyridae from the Russian platform area, and Cummings (in George, 1960) has continued usage of the generic name. In this study Plectogyra has been retained, for it is evident after examining numerous thin-sections that various stratigraphic intervals are characterized by their relative abundance of planispiral and skew-coiled species.

Endothyra flatile, n. sp.

Plate 9, Figures 1, 12, 17

Test discoidal, involute, umbilicate, periphery rounded; coiling planispiral, showing rapid rate of expansion; average diameter 0.60 to 0.70 mm.; volutions 3 to 3-1/2; septa count from first to last volution 7, 8, 9; proloculus 0.060 mm.; septa medium in length, curved toward the anterior; chambers large, moderately inflated; secondary deposits consisting of a single hamulus on the chamber floor of the ultimate chamber; wall finely granular, layered, calcareous; aperture at base of apertural face.

The name of this species is derived from the Greek word "flatilus" meaning blown up or inflated.

Holotype: PF0045 (Plate 9, Figure 12); diameter 0.68 mm.

Paratypes: PF 0044 (Plate 9, Figure 1); diameter 0.62 mm.

PF 0046 (Plate 9, Figure 17); diameter 0.62 mm.

Type locality of holotype and paratypes: PF 0045, PF 0046 (RG 57-1-18); PF 0044 (RG 57-1-24), Tunnel Mountain, Alberta, from the upper part of the Mount Head formation.

Occurrence: Endothyra flatile was recognized at several horizons in the upper part of the Mount Head formation.

Remarks: This species differs from Endothyra zelleri and E. macra in having fewer volutions, larger and more inflated chambers, and a greater expansion rate. By its smaller diameter, shorter septa, greater number of whorls and hamulus, Endothyra flatile is differentiated from E. arrecta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra macra E. J. Zeller

Plate 11, Figure 8

Endothyra macra E. J. Zeller, 1957, Jour. Paleont., Vol. 31, No. 4, page 702, Plate 80, Figures 7, 14.

Test discoidal, involute, umbilicate on both sides, coiling planispiral showing an uneven expansion rate, average

diameter 0.69 mm.; volutions 4; septal count from first to fourth volution, 6, 8, 10, 11; septa of medium length and curved toward the anterior; chambers slightly inflated; wall calcareous, granular, layered; aperture slit-like and at base of apertural face.

Hypotype: PF 0086, diameter 0.68 mm.

Locality of Hypotype: PF 0086 (MR 34-974), Mount Rae, Alberta, from 40' below the top of the Mount Head formation.

Remarks: The close-coiled initial portion is characteristic of this species. Endothyra macra differs from E. zelleri by having a larger average diameter and less uniform expansion rate. It is known also from the upper Brazer limestone of Utah, where it occurs in the upper part of the E. zelleri (E. symmetrica) zone.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra robusta, n. sp.

Plate 7, Figure 15; Plate 8, Figures 1, 4;
Plate 10, Figures 1, 13; Plate 11, Figures 12, 14

Test globular, involute, umbilicate on both sides, periphery broadly rounded, coiling planispiral, but showing slight irregularity of the initial coiled portion; average diameter 1.20 mm.; volutions 4; chambers in the outer vol-

ution 10 to 12, exhibiting little inflation between sutures; septa short, thick, curved toward the anterior; secondary deposits consisting of a broad-based hamulus in the ultimate chamber, unresorbed bases in the preceding chambers, and additions to the posterior tip of the septa; wall thick (0.04 mm.), finely granular, calcareous, layered; aperture at base of apertural face.

This species name is derived from the Latin word "robustus" meaning strong or robust.

Holotype: (Plate 8, Figure 1), PF 0173, diameter 1.20 mm.

Paratypes: (Plate 7, Figure 15), PF 0172, diameter 1.08 mm.

(Plate 8, Figure 4), PF 0174, diameter 1.12 mm.

(Plate 10, Figure 1), PF 0176, diameter 1.02 mm.

(Plate 10, Figure 13), PF 0179, diameter 0.98 mm.

(Plate 11, Figure 12), PF 0182, diameter --

(Plate 11, Figure 14), PF 0183, diameter 1.20 mm.

Type locality of holotype: PF 0173 (RG 57-1-30), Tunnel Mountain, Alberta, from the middle Mount Head formation.

Type locality of paratypes: PF 0172, PF 0174 (RG 57-1-30); PF 0176 (RG 57-1-18), Tunnel Mountain, Alberta from the middle and upper Mount Head respectively; PF 0179, Crowsnest Ridge, Alberta, from the upper part of the Mount Head

formation; PF 0182, 83 (MR 34-477), Mount Rae, Alberta, from 50' below the top of the same unit.

Occurrence: Endothyra robusta is a common species of the middle Mount Head at Tunnel Mountain, and also of the interval examined 50' below the top of the formation at Mount Rae.

Remarks: The United States Cordilleran species, Endothyra hamula Woodland, and E. prodigiosa Armstrong, belong to the same group of large endothyrids (characterized by a prominent hamulus in the ultimate chamber) as Endothyra robusta. The last-mentioned differs from both Woodland's and Armstrong's species in having a more globular outline, and thicker wall and septa. Endothyra hamula is known from the upper Deseret limestone of Utah, and E. prodigiosa, from the Arroyo Peñasco formation of New Mexico.

Thick-walled, globular species of Endothyranopsis, a Lower Visean Eurasian genus, are differentiated from Endothyra robusta by lacking diagnostic secondary deposits. The wall structure of Endothyranopsis is described as being typically perforate and agglutinate, whereas, the wall of E. robusta appears finely granular, although the occasional alignment of calcite crystals in the latter suggest the rudimentary development of a perforate wall.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra zelleri McKay

Plate 7, Figures 7, 12, 13, 14; Plate 8, Figure 10

Endothyra symmetrica E. J. Zeller, 1957, Jour. Paleont., Vol. 31, No. 4, page 701, Plate 75, Figures 13, 14, 19; Plate 78, Figures 8, 9; Plate 80, Figure 6.

Endothyra symmetrica E. J. Zeller. Woodland, Jour. Paleont., Vol. 32, No. 5, page 800, Plate 101, Figures 7, 9, 10.

(Non) Endothyra symmetrica Morozova, 1949.

Test discoidal, involute, umbilicate on both sides; periphery rounded to slightly angular; coiling planispiral; average diameter 0.55 mm.; volutions 4 to 5; septal count from first to last volution 7, 8, 10, 11; chambers moderately inflated; septa of medium length, curved in an anterior direction; secondary deposits consisting of a hamulus in the ultimate chamber and occasional low tumuli on the chamber floor of preceding chambers; wall thin, finely granular, calcareous, layered; aperture slit-like at base of apertural face.

The name Endothyra symmetrica E. J. Zeller (1957) is preoccupied by E. symmetrica Morozova (Toomey, 1959); consequently, the species has been renamed by the present writer in honour of one of North America's foremost endothyrid experts, E. J. Zeller.

Hypotypes: PF 0047, diameter 0.60 mm.

PF 0049, diameter 0.54 mm.

PF 0050, diameter 0.62 mm.

PF 0051, diameter 0.60 mm.

PF 0053, diameter 0.64 mm.

Locality of hypotypes: PF 0047 (RG 57-1-33); PF 0049-51 (RG 57-1-30); PF 0053 (RG 57-1-29), Tunnel Mountain, Alberta, from the middle and upper part of the Mount Head formation.

Occurrence: This species is common through the middle and lower upper part of the Mount Head formation at Tunnel Mountain.

Remarks: Endothyra zelleri is a zonal index species in the upper Brazer formation, and upper Deseret-lower Humbug formation, Utah; the upper Redwall limestone, Nevada; and the upper Escabrosa limestone, Arizona.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. A

Plate 6, Figures 1, 3

Test discoidal, involute, umbilicate on both sides; periphery rounded; coiling planispiral showing an even rate of expansion; average diameter 0.60 mm.; volutions 3 1/2 to 4; chambers very slightly inflated; septal count from first to last volution, 7, 8, 10; septa long, thin, anteriorly directed; secondary deposits consisting of a hamulus in the ultimate chamber, and rare unresorbed nodes in the preceding

volutions; wall thin, layered, finely granular, calcareous; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0056, PF 0055 (RG 57-1-66), Tunnel Mountain, Alberta, from the upper part of the "Livingstone" formation.

Occurrence: This species is common in the fossiliferour portion of the upper "Livingstone" formation at Tunnel Mountain immediately above and below bed RG 57-1-66.

Remarks: Endothyra sp. A is differentiated from E. zelleri on the basis of its fewer volutions, longer and thinner septa, and more even rate of expansion; from E. spiroides it differs in possessing fewer volutions and having a smaller septal count.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. B

Plate 6, Figures 11, 15

Test discoidal, involute, umbilicate on both sides; periphery rounded, coiling planispiral; average diameter 0.75 mm.; volutions 3 to 4; septa of medium length and directed anteriorly; secondary deposits consisting of a hamulus in the ultimate chamber; wall relatively thick (0.013 mm.), granular, calcareous, layered; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0057, PF 0059 (RG 57-1-41), Tunnel Mountain, Alberta, from the lower part of the Mount Head formation.

Remarks: Endothyra sp. B lies between the larger E. robusta and smaller E. zelleri in size and wall thickness.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. C

Plate 9, Figures 9, 13

Test discoidal, involute becoming evolute in the outer portion; periphery rounded with a tendency towards angulation; coiling planispiral; diameter 0.78 mm.; volutions 4 1/2; chambers in outer volution 12 to 13; septa of medium length and curved anteriorly; secondary deposits not observed; wall granular, calcareous, layered; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0067 (RG 57-1-21); PF 0068 (RG 57-1-20), Tunnel Mountain, Alberta, from the upper part of the Mount Head formation.

Remarks: Endothyra sp. C differs from E. zelleri in its more even rate of expansion, greater number of chambers per volution, larger diameter and evolute coiling.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. D

Plate 9, Figures 18, 21

Test discoidal, mainly involute, umbilicate, planispiral showing slight irregularity in the tightly coiled initial portion; diameter 0.36 mm.; volutions 4 1/2 to 5; chambers inflated, 11 to 12 in the outer volution, septa shortened by resorption, anteriorly directed; secondary deposits consisting of a hamulus in the ultimate chamber and additions to the posterior tip of the septa; wall finely granular, calcareous, layered; aperture slit-like at base of apertural face.

Locality of figured specimen: PF 0070 (RG 57-1-20), Tunnel Mountain, Alberta, from the upper beds of the Mount Head formation.

Remarks: The short, resorbed septa, irregular coiling, and small size are also characteristic of the form Endothyra taedia E. J. Zeller, however, it differs from the Alberta species in having fewer volutions and a smaller septal count.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. E

Plate 3, Figure 1, 5

Test laterally compressed; coiling planispiral showing an even rate of expansion; diameter 0.70 mm.; volutions 4 to 5; septa noticeably short, and directed anteriorly, imperceptible in the initial portion; chambers of moderate

size, 10 in the outer volution; secondary deposits consisting of a continuous layer in the ultimate whorl; wall finely granular, calcareous, questionably layered; nature of aperture not known.

Locality of figured specimen: PF 00123 (RG 60-1-83), Morro Creek, Jasper, Alberta, from the lower Rundle.

Remarks: The even expansion rate; short, resorbed septa, and large diameter make this species diagnostic.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. F

Plate 6, Figures 2, 5, 7

Test discoidal, involute to evolute, coiling planispiral, showing an even expansion rate; diameter 0.50 mm.; volutions 5; septal count not known; septa short, anteriorly directed; wall calcareous, finely granular, layered; nature of aperture not known.

Locality of figured specimens: PF 0074-76 (RG 57-1-66), Tunnel Mountain, Alberta, from the upper "Livingstone".

Remarks: This species is most like Endothyra spiroides E. J. Zeller, but differs in having a greater septal count, and in being evolutely coiled.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus GRANULIFERELLA E. J. Zeller, 1957

Granuliferella granulosa E. J. Zeller

Plate 1, Figures 9, 11, 12

Granuliferella granulosa E. J. Zeller, 1957, Jour. Paleont., Vol. 31, No. 4, page 695, Plate 77, Figures 1, 7, 8, 14, 19, 20; Plate 78, Figure 2; Plate 79, Figures 3-5, 20-22; Plate 81, Figures 4, 5, 7, 8, 10; Plate 82, Figures 6, 7.

Granuliferella granulosa E. J. Zeller. Woodland, 1958, Jour. Paleont., Vol. 32, No. 5, page 796, Plate 99, Figures 7, 8, 12, 14.

Test discoidal, involute, umbilical area broad, periphery broadly rounded; coiling plectogyroid, showing moderate amount of distortion of the coiling plane; average diameter 0.60 mm.; volutions 2 to 2 1/2; proloculus 0.08 mm. in diameter; chambers in outer volution 7, large, moderately inflated; septa short, stubby, slightly curved toward the anterior; septa and wall thick, coarsely granular, calcareous, single-layered; aperture slit-like at base of apertural face.

Hypotypes: PF 0030, diameter 0.60 mm.
PF 0031, diameter 0.56 mm.
PF 0032, diameter 0.66 mm.

Locality of Hypotypes: PF 0030-32 (RG 60-1-37), Morro Creek, Jasper, Alberta, from the lower beds of the "Pekisko" member of the Banff formation.

Occurrence: At Jasper, Granuliferella granulosa is most common in the one horizon of the "Pekisko," however rare specimens also occur in the "Shunda" member.

Remarks: Granuliferella granulosa differs from G. tumida in its thicker walls and greater distortion of the coiling plane. The holotype of the species is from the base of the Mission Canyon formation, Montana, but also occurs in the lower and middle Madison limestone of Utah and Wyoming.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Granuliferella tumida E. J. Zeller

Plate 3, Figures 16, 17, 21

Granuliferella tumida E. J. Zeller, 1957, Jour. Paleont., Vol. 31, No. 4, page 696, Plate 77, Figures 3, 21, 22; Plate 81, Figures 14, 15, 17, 18.

Granuliferella tumida E. J. Zeller. Woodland, Jour. Paleont., Vol. 32, No. 5, page 797, Plate 100, Figures 6, 7.

Test free, discoidal, involute, umbilicate on both sides, periphery broadly rounded, coiling plectogyroid, showing a low degree of distortion

of the coiling plane; average diameter 0.60 mm.; volutions 2 1/2 to 3; chambers large, inflated, slightly asymmetrical, 6 to 8 in the outer volution; septa thin, short, curved anteriorly; secondary deposits consisting of rudimentary additions to the posterior tip of the septa; wall finely granular, calcareous, single-layered; aperture slit-like at base of apertural face.

Hypotypes: PF 0027, diameter 0.54 mm.
PF 0028, diameter 0.60 mm.
PF 0029, diameter 0.60 mm.

Locality of hypotypes: PF 0027-29, Peace River, Alberta, Shell Cadotte No. 1 Well (Lsd. 16, Sec. 23, Tp. 55, R. 19, W. 5th Mer.), from 468' above the base of the Banff.

Remarks: Granuliferella tumida is differentiated from G. granulosa by its thinner wall, more inflated chambers and lower degree of distortion of the coiling plane. This species has been recognized in the Joana and upper Gardner limestone of Utah, and in the basal Madison limestone of Wyoming.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus GRANULIFERELLOIDES, n. gen.

Type species: Granuliferelloides jasperensis, n. sp.

The test is plectogyroidly coiled in the initial portion and uniserial in the outer. Initial part has 1 1/2 to 2 volutions

with 6 chambers in the outer whorl. In the uniserial portion there are approximately 6 to 7 chambers, which increase uniformly in size. The wall is calcareous, single-layered, coarsely granular, and thick (0.03 mm.). Although not observed, the aperture is presumed terminal.

Woodland (1958) described a thick-walled uniserial species from Utah which he provisionally placed in Granuliferella. The initial coiled portion of his species is near to G. granulosa in diameter, and thus bears a closer relationship to the thick-walled granuliferellids than do the observed Canadian species of Granuliferelloides.

Endothyranella differs from Granuliferelloides in having a thinner wall, the primary structure of which is composed of transverse fibres; as well as having a greater number of volutions.

Granuliferelloides jasperensis, n. sp.

Plate 2, Figures 7, 11, 12, 16

Test elongate, initial portion spirally coiled, becoming rectilinear, uniserial in the terminal portion. Spiral portion: coiling plectogyroid showing a small amount of angular distortion; average diameter 0.30 mm.; volutions 1 1/2 to 2; chambers moderately inflated, 5 in the outer whorl; septa short, thick, curved anteriorly; aperture at base of apertural face. Uncoiled portion: approximately

6 chambers in terminal portion, increasing uniformly in size, height of terminal chamber 0.12 mm.; septa short, maximum width of uncoiled portion 0.16 mm., average total length 0.67 mm., maximum length 0.86 mm.; wall granular, calcareous, single layered, thick; aperture not observed.

The name of this species is derived from the locality at which it was first observed, Morro Creek, Alberta.

Holotype: (Plate 2, Figure 11), PF 0035, diameter of initial portion 0.28 mm., length of uniserial portion 0.67 mm.

Paratypes: (Plate 2, Figures 7, 12, 16),
PF 0034, diameter 0.30 mm.; length--
PF 0036, diameter 0.30 mm.; length--
PF 0037, diameter 0.32 mm.; length 0.60 mm.

Type locality of holotype and paratypes: Morro Creek, Alberta, PF 0035 (RG 60-1-57); PF 0034, PF 0036 (RG 60-1-57); PF 0037 (RG 60-1-59), from the "Shunda" member of the Banff formation.

Occurrence: Granuliferelloides jasperensis is a common species in the "Shunda" at Morro Creek.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus CHERNYSHINELLA Lipina, 1955

Chernyshinella morroensis, n. sp.

Plate 2, Figures 1, 2, 5, 8, 9

Test discoidal, involute becoming evolute in the outer whorls; umbilical depression broad on one side, periphery rounded; coiling somewhat irregular, pseudo-plectogyroid, axis of coiling plane going through a 90 degree shift between ultimate and penultimate whorls; average diameter 0.27 to 0.30 mm.; volutions 2 1/2; chambers in the last volution approximately 6, inflated, asymmetrical; septa typically short, strongly directed toward the anterior; secondary deposits sometimes present as nodes on the chamber floor; wall finely granular, calcareous, three-layered; nature of aperture not known.

This species is named for the locality at which it was first encountered, Morro Creek, Jasper, Alberta.

Holotype: (Plate 2, Figure 2), PF 0087, diameter 0.27 mm.

Paratypes: (Plate 2, Figures 1, 5, 8, 9),
PF 0086, diameter 0.28 mm.
PF 0088, diameter 0.28 mm.
PF 0089, diameter 0.29 mm.
PF 0090, diameter 0.24 mm.

Type locality of holotype: PF 0087 (RG 60-1-34), Morro Creek, Alberta, from the Banff Member B.

Type locality of paratypes: PF 0086 (RG 60-1-34), Morro Creek, Alberta, from the Banff Member B; PF 0088-90 (RG 60-1-50), from the "Shunda".

Occurrence: Chernyshinella morroensis is found in the uppermost beds of Banff Member B and the lower part of the "Shunda" at Morro Creek.

Remarks: This species has been placed in Chernyshinella on the basis of the asymmetric, inflated chambers, and small number of volutions, however, the layered wall structure suggests a close affinity to Plectogyra. The Alberta species is most like Plectogyra anteflexa E. J. Zeller from the lower part of the P. tumula zone of Wyoming and Montana, but the latter has more volutions and chambers than Chernyshinella morroensis.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra arrecta, n. sp.

Plate 8, Figures 8, 12; Plate 9, Figure 11

Test discoidal, involute, umbilicate, periphery broadly rounded; coiling plectogyroid showing little distortion of the coiling plane; rate of expansion rapid; average diameter 0.75 mm.; volutions 2; septal count from first to

last volution 7, 9; proloculus 0.08 mm.; septa long, forming an almost perpendicular angle to the wall in the ultimate whorl; chambers large, and slightly inflated; wall granular, calcareous, layered; apertural face noticeably high, aperture at base.

The name of this species is derived from the Latin word "arrectus" meaning steep or erect, and referring to the septal face.

Holotype: (Plate 8, Figure 8), PF 0041, diameter 0.73 mm.

Paratypes: (Plate 8, Figure 12), PF 0042 diameter 0.82 mm.

(Plate 9, Figure 11), PF 0043, diameter 0.88 mm.

Type locality of holotype: PF 0041 (RG 57-1-29), Tunnel Mountain, Alberta, from the lower upper Mount Head formation.

Type locality of paratypes: PF 0042 (RG 57-1-29); PF 0043 (RG 57-1-21), Tunnel Mountain, Alberta from the lower upper Mount Head formation.

Occurrence: Plectogyra arrecta is most common in the lower bed RG 57-1-29 of the upper Mount Head, but occurs also in several overlying horizons of the formation at Tunnel Mountain.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra incrassata, n. sp.

Plate 7, Figures 10, 11, 16, 17; Plate 11, Figures 9, 10, 7

Test sub-elliptical, involute to evolute in the outer whorl, umbilical depression on one side, periphery broadly rounded; coiling plectogyroid, showing strong distortion of the coiling plane; average diameter 0.80 mm.; volutions 4 1/2 to 5; chambers large, inflated, 6 in the outer volution; septa of moderate length, curved toward the anterior; secondary deposits consisting of a hamulus in the final chamber, thorn-like projections in the preceding chambers of the outer volution and additions to the posterior tip of the septa (prominent in the last few chambers); wall finely granular, calcareous, layered; proloculus 0.03 mm.; apertural face curved, aperture at base of apertural face.

The name is derived from the Latin word "incrassatus" meaning thickened, which refers to the nature of secondary deposition on the posterior tip of the septa.

Holotype: (Plate 7, Figure 11), PF 0103, diameter 0.86 mm.

Paratypes: (Plate 7, Figures 10, 16, 17),
PF 0102, diameter 0.86 mm.
PF 0103A, diameter 0.86 mm.
PF 0104, diameter 0.77 mm.

(Plate 11, Figures 9, 10, 7)

PF 0184, diameter 0.70 mm.

PF 0185, diameter 0.78 mm.

PF 0187, diameter 0.78 mm.

Locality of holotype: PF 0103 (RG 57-1-30), Tunnel Mountain, Alberta, from the middle Mount Head formation.

Locality of paratypes: PF 0102, PF 0103A, PF 0104 (RG 57-1-30), Tunnel Mountain, Alberta, from the middle Mount Head; PF 0184, PF 0185 (MR 34-974), Mount Rae, Alberta, from 50' below the top of the same formation.

Occurrence: Plectogyra incrassata is found through the middle Mount Head formation at Tunnel Mountain, and in the interval 40-50' below the top of the same unit at Mount Rae.

Remarks: This large plectogyrid is close in size and in manner of coiling to Plectogyra sp. C from the lower Mount Head formation, but shows more extensive secondary deposition.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra kleina Woodland

Plate 10, Figures 8, 9

Plectogyra kleina Woodland, 1958, Jour. Paleont., Vol. 32, No. 5, page 799, Plate 99, Figures 1, 4, 6.

Test laterally compressed, involute, umbilicate on one side; coiling plectogyroid with a low degree of distortion; maximum diameter 0.32 mm.; average diameter 0.27 mm.; volutions 2; chambers large in proportion to test size, 6 in the outer volution; septa long and only slightly directed toward the anterior; secondary deposits consisting of continuous to discontinuous secondary layering of the chamber floor; wall calcareous, finely granular, layered; nature of aperture not known.

Hypotypes: PF 0164, diameter 0.32 mm.
PF 0165, diameter 0.24 mm.

Locality of hypotypes: PF 0164, 65 (RG 57-1-17), Tunnel Mountain, Alberta, from the lower beds of the Etherington formation.

Occurrence: Rare specimens of Plectogyra kleina occur in the lowermost beds of the Etherington formation, Tunnel Mountain.

Remarks: Plectogyra kleina is smaller than P. lanceolata and shows secondary deposition on the chamber floor. This species is recognized in the lower Great Blue limestone of central Utah.

Repository: Research Council Alberta Micropaleontology Type Collection.

Plectogyra lanceolata Woodland

Plate 4, Figures 9, 12, 18, 20, 22; Plate 6, Figures 14, 18

Endothyra lanceolata Woodland, 1959, Jour. Paleont., Vol. 32, No. 5, page 800, Plate 101, Figures 1-3.

Test small, discoidal, involute, and umbilical depression greater on one side; periphery broadly rounded; coiling plectogyroid, showing rapid rate of expansion; average diameter 0.35 to 0.38 mm., maximum diameter 0.45 mm.; volutions 2; chambers large in proportion to test size; septa long thin, curved toward the anterior; wall thin, finely granular, layered; aperture at base of apertual face.

Hypotypes: PF 0093, diameter 0.43 mm.
PF 0094, diameter 0.45 mm.
PF 0095, diameter 0.36 mm.
PF 0096, diameter 0.34 mm.
PF 0097, diameter 0.40 mm.
PF 0098, diameter 0.41 mm.
PF 0099, diameter 0.38 mm.

Locality of hypotypes: PF 0093 (MD 36-940), Mount Darrah, from the upper part of the "Livingstone" formation; PF 0094 (RG 59-2-31), Moose Mountain, Alberta, from the lowermost beds of the Turner Valley formation; PF 0095-96, (RG 57-1-87), PF 0097 (RG 57-1-75), PF 0098 (RG 57-1-51), PF 0099 (RG 57-1-38), Tunnel Mountain, Alberta, from the upper part of the "Livingstone" formation, the last two from the lower part of the Mount Head formation.

Occurrence: Plectogyra lanceolata is known from several localities in the Canadian Rockies, including Moose Mountain, where it occurs in the lowermost beds of the Turner Valley formation; Mount Darrah, where it occurs in the upper part of the Livingstone formation; and Tunnel Mountain, where it is found commonly in the upper part of the "Livingstone" formation.

Remarks: This species is diagnostic because of its small size, thin wall and septa, and few volutions. It has been placed in Plectogyra because of the definite distortion of the coiling plane. The spear-shaped addition described by Woodland (1958) as being characteristic of the form is considered by the present writer to be only a broken chamber, and has been discounted as a feature of the species.

Repository: Research Council of Alberta Microplaeontology Type Collection.

Plectogyra sp. cf. P. spinosa Chernysheva

Plate 2, Figures 3, 4, 13, 17; Plate 4, Figure 12

Test discoidal, involute in the inner whorls, becoming evolute in the outer, periphery rounded, umbilical area broadly depressed; coiling plectogyroid showing moderate to fairly strong distortion of the coiling plane; average diameter 0.50 mm.; volutions 4; chambers in the outer volution 8 to 9; septa directed anteriorly; secondary deposits

consisting of diagnostic curved hamuli that are unresorbed even in the earliest portion; wall finely granular, calcareous, layered; aperture at base of apertural face.

Locality of figured specimens: PF 0108-11 (RG 60-1-50), Morro Creek, Jasper, Alberta, from the "Shunda" member of the Banff, and lower Rundle; PF 0107 (RG 59-2-22), Moose Mountain, Alberta, from the upper part of the Pekisko formation.

Occurrence: This species is found in the "Shunda" and rarely in the lower Rundle at Morro Creek, and in the upper part of the Pekisko at Moose Mountain.

Remarks: Plectogyra sp. cf. P. spinosa differs from the Eurasian species in its larger average diameter (0.50 mm. of the Alberta species compared to 0.30 mm. of P. spinosa) and outer evolutely coiled portion, although both species possess diagnostic hook-shaped deposits.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra tumula E. J. Zeller

Plate 1, Figures 4, 5; Plate 3, Figures 11, 15;
Plate 4, Figures 7, 9

Plectogyra tumula E. J. Zeller, 1957, Jour. Paleont., Vol. 31, No. 4, page 697, Plate 77, Figures 5, 6, 11; Plate 79, Figures 7, 8, 9, 12, 23; Plate 82, Figures 3, 4, 16, 17.

Plectogyra tumula E. J. Zeller. Woodland, 1958, Jour. Paleont., Vol. 32, No. 5, page 798, Plate 101, Figures 12, 14, 15; Plate 102, Figure 13.

Test laterally compressed, umbilicate on one side, periphery broadly rounded; coiling plectogyroid, showing moderate to strong distortion of the coiling plane; average diameter 0.68 mm.; volutions 4; septa medium length and curved anteriorly; chambers slightly inflated, approximately 8 in the outer volution; secondary deposits consisting of symmetrical or massive tumuli on the chamber floor; wall finely granular, calcareous, layered; aperture slit-like at base of apertural face.

Hypotypes: PF 0112, diameter 0.72 mm.
PF 0113, diameter 0.68 mm.
PF 0138, diameter 0.77 mm.
PF 0151, diameter 0.63 mm.

Locality of hypotypes: PF 0128, PF 0129 (RG 60-1-34), Morro Creek, Alberta, from the Banff Member B; PF 0112, PF 0113 (RG 59-2-22), Moose Mountain, Alberta, from the upper Pekisko formation; PF 0138, PF 0151, Bighorn Creek, Alberta, from the lower part of the Shunda formation.

Remarks: Plectogyra tumula is characterized by its massive tumuli. The earliest representative shows extensive secondary deposits in the initial portion, but later ones have the tumuli confined to the outer two whorls. Plectogyra trachida E. J. Zeller is a closely related species in which the secondary deposits are more asymmetric, and less massive. The deposits of P. trachida are intermediate between the massive symmetrical tumuli of P. tumula and the hook-shaped hamuli of P. spinosa.

Plectogyra tumula is the zonal index in the lower Madison of Utah and Wyoming, and the upper Lodgepole and lower Mission Canyon of Montana, and the upper Gardner dolomite of Utah.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. aff. P. tumula E. J. Zeller

Plate 1, Figure 1

Test laterally compressed, umbilicate on one side, periphery broadly rounded; coiling plectogyroid showing

moderate distortion of the coiling plane; maximum diameter 0.76mm.; volutions 2 to 2 1/2; chambers large, inflated, 5 in the outer volution; septa noticeably short, strongly directed toward the anterior; secondary deposits consisting of diagnostic symmetrical massive tumuli; wall granular, calcareous, layered?, aperture at base of apertural face.

Locality of figured specimen: PF 0115 (RG 60-1-31), Morro Creek, Jasper, Alberta, from the upper part of Banff Member A.

Remarks: Plectogyra sp. aff. P. tumula is an early representative of the tumulate plectogyrids. It has larger chambers and fewer volutions than P. tumula, but shows the characteristic massive secondary deposits.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. A

Plate 4, Figure 4

Test laterally compressed, umbilicate, coiling plectogyroid showing little distortion of the coiling plane; diameter 0.96 mm.; volutions 4; chambers in the outer volution 8, large, inflated; septa of medium length, curved toward the anterior; secondary deposits consisting of asymmetric projections extending forward from the chamber floor, and additions to the posterior tip of the septa; wall calcareous, granular, layered; aperture slit-like at base of apertural face.

Locality of figured specimen: PF 0084 (RG 59-2-22), Moose Mountain, Alberta, from the upper part of the Pekisko formation.

Remarks: Except for its larger size, this species is similar to Plectogyra sp. B from Morro Creek in having asymmetric secondary deposits and showing signs of resorption in the initial portion.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. B

Plate 3, Figure 2

Test laterally compressed, coiling plectogyroid, showing moderate amount of distortion; diameter 0.68 mm.; volutions approximately 4, septa directed toward the anterior, chambers in outer volution 8; secondary deposits consisting of

hamuli in the outer volution with evidence of resorbed deposits in the earlier volutions; wall thick, granular, calcareous, layered; aperture not observed.

Locality of figured specimen: PF 0083 (RG 60-1-83), Morro Creek, Jasper, Alberta, from the lower part of the Rundle formation.

Remarks: Plectogyra sp. B like P. sp. cf. P. spinosa is characterized by secondary hook-shaped deposits, but the former has a larger diameter, fewer chambers per volution, and less extensive secondary deposits in the initial portion.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. C

Plate 6, Figures 16, 19

Plectogyra sp., E. J. Zeller, 1957, Jour. Paleont., Vol. 31, No. 4, Plate 75, Figure 32.

Test elliptical, involute, greater umbilical depression on one side, periphery broadly rounded; coiling plectogyroid, showing moderate distortion; maximum diameter 0.94 mm., average diameter 0.80 mm.; volutions approximately 4; chambers in outer volution 7, inflated, large; septa

noticeably long, thin and curved toward the anterior; secondary deposits consisting of low nodes on the chamber floor, and a thin hamulus in the ultimate chamber; wall thin, finely granular, calcareous, layered; apertural face high, rounded; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0126, PF 0127 (RG 57-1-41), Tunnel Mountain, Alberta, from the lower part of the Mount Head formation.

Remarks: Plectogyra sp. C differs from P. incrassata in having thinner walls and septa, a lower degree of distortion of the coiling plane, and less extensive secondary deposits.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. D

Plate 9, Figures 5, 10

Test laterally compressed, umbilicate on one side, involute becoming evolute in the outer whorl; coiling plectogyroid exhibiting strong distortion of the coiling plane; average diameter 0.70 mm.; volutions 4 to 4 1/2; chambers large, inflated, 6 to 7 in the outer volution; septa curved toward the anterior; wall granular, calcareous; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0160 (RG 57-1-21), PF 0161 (RG 57-1-20), Tunnel Mountain, Alberta, from the upper beds of the Mount Head formation.

Remarks: In lacking diagnostic secondary deposits this species differs from P. incrassata and P. sp. C of the middle and lower Mount Head formation. It exhibits the most pronounced distortion of the coiling plane as yet observed in the plectogyrids.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. E

Plate 10, Figure 3

Test large, globular, involute to barely evolute in the outer portion, umbilicate on one side; coiling plectogyroid showing only moderate amount of distortion of the coiling plane; maximum diameter 1.36 mm., average diameter 1.12 mm.; volutions 4 1/2; septa thick, curved slightly toward the anterior; wall thick 0.04 mm., coarsely granular, calcareous, layered; aperture at base of apertural face.

Locality of figured specimen: PF 0178 (RG 57-1-18), Tunnel Mountain, Alberta, from the upper part of the Mount Head formation.

Remarks: Plectogyra sp. E represents the largest

endothyrid encountered in this study. It belong to the same group of Endothyridae as the Russian Lower Visean form, P. omphalota (Rauser-Cernoussova and Reitlinger). Both species are characterized by their large, globular outlines, thick walls and septa, and low degree of distortion of the coiling plane, although the Russian species has a larger diameter and more pronounced secondary deposits than the Alberta species.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Plectogyra sp. F

Plate 1, Figures 2, 3, 6, 8

Test discoidal, evolute, umbilical depression greater on one side, periphery broadly rounded; coiling plectogyroid to almost planispiral; diameter 0.70 to 0.80 mm.; proloculus 0.06 mm.; volutions 4; chambers large, inflated; septa of medium length, curved toward the anterior; secondary deposits consisting of tumuli, but observed in only one specimen; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0116-119 (RG 60-1 -34), Morro Creek, Alberta, from the upper part of Banff Member B.

Remarks: In its evolute coiling habit and number of volutions, Plectogyra sp. F is comparable to the described holotype of P. tumula, but lacks the diagnostic tumuli.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family FUSULINIDAE Moller, 1878, emend Dunbar

Genus EOSTAFFELLA Rauser Cernoussova, 1948

Remarks: Eostafella is considered to be the earliest representative of the fusulinids, however its relationship to the large schwagerinids and related genera is not clear. The main line of development from this genus is to the discoidal ozawainellids and staffellids (Miklukomaklai, et. al., 1958).

Eostafella sp. A

Plate 9, Figures 2, 3, 4, 15, 20

Test discoidal, compressed, early stages of coiling involute becoming evolute in the outer 2 to 3 volutions; umbilical area a broad shallow depression, periphery rounded; coiling variable in the initial portion, attaining constant planispiral coiling in the outer evolute portion; average diameter 0.44 mm., length to height ratio 3:1, volutions 5, septa short, and only slightly directed toward the anterior; secondary deposits consisting rarely of a small hamulus in the ultimate chamber; wall thin, finely granular, layered, calcareous; aperture slit-like at base of apertural face.

Locality of figured specimens: PF 0077-81 (RG 57-1-24), Tunnel Mountain, Alberta, from the upper beds of the Mount Head formation.

Occurrence: This species is found throughout the upper Mount Head formation, but is most common in the interval RG 57-1-24.

Remarks: As originally described by Rauser-Cernoussova (1948), Eostaffella is a small evolute form with a variable plane of coiling, and thin, undifferentiated or three-layered fusulinid wall showing semi-continuous chomata. Except for lacking chomata, the Alberta species resembles this primitive fusulinid. For the present Eostaffella is differentiated from Millerella on the basis of the plectogyroid coil (by this writer).

Repository: Research Council of Alberta Micropaleontology Type Collection.

Eostaffella sp. B

Plate 9, Figures 6, 7, 8

Test small, laterally compressed, involute becoming evolute in the outer portion; coiling plectogyroid, showing a high degree of distortion, in some cases going through two 90 degree shifts of the coiling plane; average diameter 0.23 to 0.30 mm.; volutions 4; chambers inflated, asymmetrical, 8 in the outer volution; septa short and anteriorly directed; wall finely granular, calcareous, layered?; nature of aperture not known.

Occurrence: Eostaffella sp. B is found in the upper Mount Head formation, Tunnel Mountain section.

Locality of figured specimens: PF 0100-102 (RG 57-1-24), Tunnel Mountain, Alberta, from the upper part of the Mount Head formation.

Remarks: This species shows a similarity to the primitive eostaffellid, E. parva (Moller) var. shamordini Rauser-Cernoussova, 1948. The latter is evolutely coiled in the initial portion, and displays strong distortion of the coiling plane. Both species are of similar size and have no apparent secondary deposits.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus NANICELLA Henbest, 1935

Nanicella gallowayi (Thomas) was named for a species from the Upper Devonian of the mid-continent. At present the relationship between it and early Mississippian endothyrids is not clear. For fuller discussion of this genus the reader is referred to St. Jean (1957). Only one species of Nanicella is known to the writer.

Nanicella gallowayi (Thomas) Henbest

Plate 3, Figures 18, 19, 20

Nanicella gallowayi (Thomas) Henbest, 1935, Jour. Wash. Acad. Sci., Vol. 25, pages 34-35.

Endothyra gallowayi Thomas. Loranger, 1958, Rutherford Memorial Volume, Amer. Assoc. Petroleum Geol., page 191,

Plate 2, Figures 11, 12.

Test free, discoidal, evolute, umbilicate, umbilical area broad, in exterior view filled with translucent calcareous material; periphery angular; coiling planispiral; diameter 0.50 mm.; volutions 3, septal count from first to last volution 10, 14, 16+; septa long, thin; wall calcareous, single-layered; nature of aperture not known.

Hypotypes: PF 0024, diameter 0.57 mm.
PF 0025, diameter 0.40 mm.

Locality of hypotypes: PF 0024, PF 0025 were obtained from the Bear Beaumont No. 1 Well (1,373-83'), from the upper Ireton formation, Alberta.

Remarks: In most specimens the final chamber has been crushed and the nature of the aperture cannot be determined. The holotype of Nanicella gallowayi (Thomas) is from the Cerro Gordo member of the Hackberry formation, Iowa. Considerable variation in the number and size of the chambers is exhibited in the mid-continent form. The average number in the outer volution is 12 to 14, and the diameter about 0.5 to 0.6 mm.

Repository: Research Council of Alberta Micropaleontology Type Collection.

EXPLANATION OF PLATE 1

(all figures X60)

Morro Creek Section

Upper Beds - Member B, Banff Formation

Figure 1: *Plectogyra* sp. aff. *P. tumula* E. J. Zeller; horizontal axial section showing massive tumuli, PF 0115.....(p. 74)

Figures 2, 3, 6, 8: *Plectogyra* sp. F; 2, 3, oblique horizontal axial sections, PF 0116, PF 0117; 6, 8, vertical axial sections, PF 0118, PF 0119 (p. 79)

Figures 7, 13: *Spiroplectammina* spp.; longitudinal axial sections, PF 0019, PF 0020.....(p. 45)

Figure 10: *Granuliferelloides*? sp.; longitudinal axial section, PF 0035 (RG 60-1-34).

Lower Beds - "Pekisko" Member, Banff Formation

Figures 4, 5: *Plectogyra tumula* E. J. Zeller; 4, vertical axial section, PF 0128; 5, horizontal axial section, PF 0129.....(p. 73)

Figures 9, 11, 12: *Granuliferella granulosa* E. J. Zeller; 9, 12, sagittal sections, PF 0030, PF 0031; 11, axial section, PF 0032.....(p. 59)

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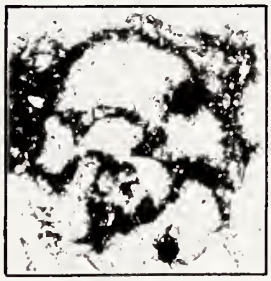

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PLATE I

EXPLANATION OF PLATE 2

(all figures X60 unless indicated otherwise)

Morro Creek Section (con't.)

Upper Beds - Member B, Banff Formation

Figures 1, 2: Chernyshinella morroensis, n. sp.; 1, vertical axial section, PF 0086; 2, horizontal axial section, PF 0087; (X90), 2 is the holotype.. (p. 64)

Lower Beds - "Pekisko" Member, Banff Formation

Figure 6: Spiroplectammina sp.; elongate axial section, PF 0021..... (p. 45)

"Shunda" Member, Banff Formation

Figures 3, 4, 13, 17: Plectogyra sp. cf. P. spinosa Chernysheva; 4, 13, 17, horizontal axial sections, PF 0109-11; 3, vertical axial section, PF 0108, (p. 71)

Figures 5, 8, 9: Chernyshinella morroensis, n. sp.; 5, 8, horizontal axial sections, PF 0088, 89; 9, vertical axial section, PF 0090 (X90).... (p. 64)

Figures 7, 11, 12, 16: Granuliferelloides jasperensis, n. gen, n. sp.; 7, incomplete specimen, horizontal axial section, PF 0034, (X90); 11, 12, 16, elongate axial sections, PF 0035-37; 11 is the genoholotype.....(p. 60)

Figures 10, 14, 15: Plectogyra spp.; 10, 14, vertical axial sections, PF 0130, PF 0133; 15, horizontal axial section, PF 0134 (RG 60-1-55).

Figures 18, 20: Plectogyra spp.; horizontal axial sections, PF 0131, 32 (RG 60-1-80).

Figure 19: Plectogyra sp.; poorly preserved horizontal axial section, PF 0135 (RG 60-1-56).

PLATE 2

Explanation of Plate 2--con't.

Figure 21: Granuliferelloides? sp., elongate section, axial, showing rudimentary cribrate aperture, PF 0033 (RG 60-1-50).

EXPLANATION OF PLATE 3

(all figures X60 unless indicated otherwise)

Morro Creek Section (con't.)

Lower Beds - Rundle Formation

Figures 1, 5: Endothyra sp. E; 1, sagittal section, PF 0012; 5, oblique section, PF 0013....(p. 58)

Figure 2: Plectogyra sp. B; oblique horizontal axial section, PF 0083.....(p. 76)

Figures 3, 4, 6, 7, 8: Plectogyra spp.; 3, 4, oblique horizontal axial sections, PF 0020, PF 0020A; 6, vertical axial section, PF 0021; 7, 8, horizontal axial sections, PF 0135, PF 0136 (RG 60-1-83).

Figure 9: Tournayella? sp.; axial section, PF 0001 (RG 60-1-83).

Figure 10: Endothyra? sp.; sagittal section, PF 0137 (RG 60-1-83).

Bighorn Creek Section

Lower Beds - Shunda Formation

Figures 11, 15: Plectogyra tumula E. J. Zeller; 11, vertical axial section, PF 0138; 15, horizontal axial section, PF 0151.....(p. 73)

Figure 12: Plectogyra sp.; vertical axial section, PF 0139.

Figure 13: Chernyshinella sp.; horizontal axial section, PF 0141 (X90).

Figure 14: Granuliferelloides sp.; elongate axial section, PF 0038.

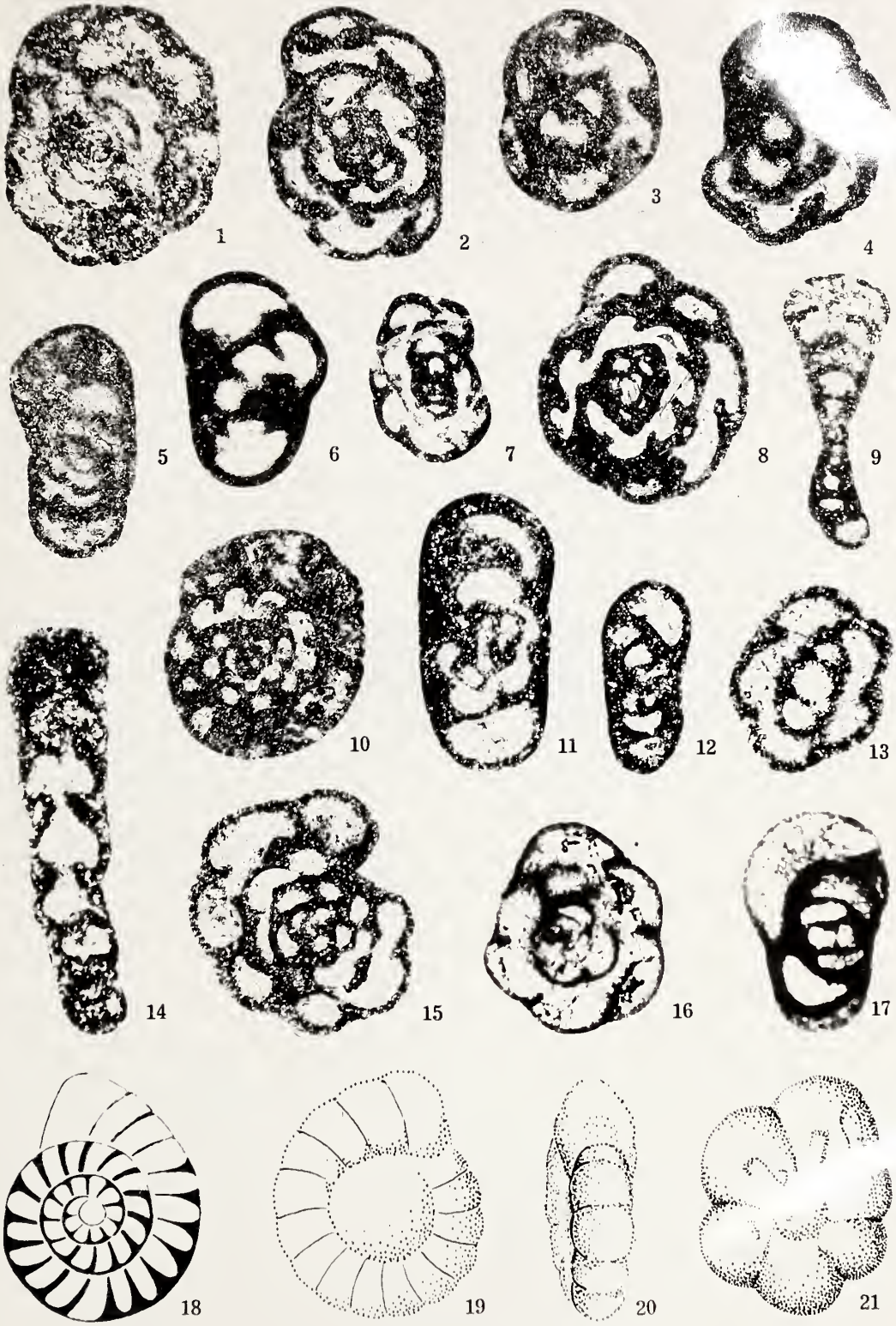

PLATE 3

Explanation of Plate 3--con't.

Shell Cadotte No. 1 Well -

Upper Beds - Banff Formation

Figures 16, 17, 21: *Granuliferella tumida* E. J. Zeller; 16, horizontal axial section, PF 0027; 17, vertical axial section, PF 0028; 21, side view, PF 0029 (X60).

Bear Beaumont No. 1 Well - 1,373 - 83'

Upper Beds - Ireton Formation (Devonian)

Figures 18, 19, 20: *Nanicella gallowayi* (Thomas) Henbest; 18, sagittal section, PF 0024 (X66); 19, side view, PF 0025; 20 peripheral view, PF 0025 (X100).

EXPLANATION OF PLATE 4

(all figures X60)

Moose Mountain Section

Pekisko Formation

Figure 1: Plectogyra sp.; vertical axial section, PF 0142 (RG 59-2-12).

Figure 2: Granuliferelloides sp.; longitudinal axial section, PF 0039 (RG 59-2-12).

Figures 3, 5, 11, 14: Plectogyra spp.; 3, 5, 11, horizontal axial sections; PF 0081, PF 0085, PF 0114; 14, vertical axial section, PF 0082 (RG 59-2-22).

Figure 4: Plectogyra sp. A; horizontal axial section, PF 0084.....(p. 76)

Figures 6, 10: Plectogyra spp.; oblique vertical axial sections, PF 0103, PF 0106 (RG 59-2-22).

Figures 7, 9: Plectogyra tumula E. J. Zeller; 7, horizontal axial section, PF 0112; 9, vertical axial section, PF 0113.....(p. 73)

Figures 8, 13: Plectogyra? spp.; horizontal axial sections; 8, PF 0091 (RG 59-2-22); PF 0092 (RG 59-2-23).

Figure 12: Plectogyra sp. cf. P. spinosa Chernysheva; horizontal axial section, PF 0107...(p. 71)

Figures 15, 16, 17: Plectogyra spp.; 15, 16, horizontal axial sections, PF 0143, PF 0144 (RG 59-2-22); 17, vertical axial section, PF 0145 (RG 59-2-23).

PLATE 4

EXPLANATION OF PLATE 5

(all figures X60 unless indicated otherwise)

Moose Mountain Section (con't.)

Pekisko Formation

Figure 1, 2: Plectogyra? spp.; 1, horizontal axial section, PF 0154; 2, vertical axial section, PF 0158 (RG 59-2-23).

Figures 3, 5: Plectogyra spp.; 3, vertical axial section, PF 0146; 5, horizontal axial section, PF 0147 (RG 59-2-23).

Figures 4, 7: Plectogyra spp.; 4, oblique horizontal axial section, PF 0022; 7, vertical axial section, PF 0023 (RG 59-2-23).

Figure 8: Plectogyra sp.; oblique horizontal axial section, PF 0148 (RG 59-2-25).

*

Turner Valley Formation

Figure 10: Plectogyra sp.; horizontal axial section, PF 0149 (RG 59-2-31).

Figure 11: Plectogyra sp.; vertical axial section, PF 0150 (RG 59-2-31).

Figure 12: Plectogyra lanceolata (Woodland); horizontal axial section, PF 0094.....(p. 70)

Figure 13: Endothyra sp.; axial section, PF 0060 (RG 59-2-38).

Mount Darrah, Alberta

Upper Beds - Livingstone Formation

Figure 9: Plectogyra lanceolata (Woodland); oblique horizontal section, PF 0093.....(p. 70)

*Figure 6: evolute foraminifer of questionable identity.

PLATE 5

Explanation of Plate 5--con't.

Tunnel Mountain Section

Upper Beds - "Livingstone" Formation

Figures 14, 19: Endothyra spp.; 14, axial section, PF 0061; 19, sagittal section, PF 0061A (RG 57-1-87).

Figures 15, 16: Plectogyra spp.; horizontal axial sections, PF 0151, PF 0152 (X120) (RG 57-1-87).

Figure 17: Plectogyra sp.; horizontal axial section, PF 0153 (RG 57-1-74).

Figures 18, 20, 22: Plectogyra lanceolata (Woodland); horizontal axial sections, PF 0095, PF 0096, PF 0097.....(p. 70)

Figure 21: Ammodiscus sp.; oblique sagittal section, PF 0003 (RG 57-1-75).

Figures 23, 24: Endothyra spp.; sagittal sections, PF 0062 (RG 57-1-75); PF 0063 (RG 57-1-74).

EXPLANATION OF PLATE 6

(all figures X60)

Tunnel Mountain Section (con't.)

Upper Beds - "Livingstone" Formation

Figures 1, 3: Endothyra sp. A.; sagittal sections, PF 0055, PF 0056.....(p. 54)

Figures 2, 5, 7: Endothyra sp. F.; 2, 7, oblique sagittal sections, PF 0074, PF 0076; 5, axial section, PF 0075.....(p. 58)

Figures 4, 12: Endothyra spp.; sagittal sections, PF

Figures 6, 9: Plectogyra spp.; oblique horizontal axial sections, PF 0155, PF 0156

Figure 8: Plectogyra sp., axial section, PF 0125 (RG 57-1-65).

Figure 10: Ammodiscus sp. A; sagittal section, PF 0004 (p. 38)

Lower Beds - Mount Head Formation

Figures 11, 15: Endothyra sp. B; 11, axial section, PF 0057; 15, sagittal section, PF 0059.....(p. 55)

Figures 13, 17: Endothyra spp.; sagittal sections, PF 0058, PF 0065A (RG 57-1-41).

Figures 14, 18: Plectogyra lanceolata (Woodland); horizontal axial sections, PF 0098, PF 0099.....(p. 70)

Figures 16, 19: Plectogyra sp. C; horizontal axial sections, PF 0126, PF 0127.....(p. 77)

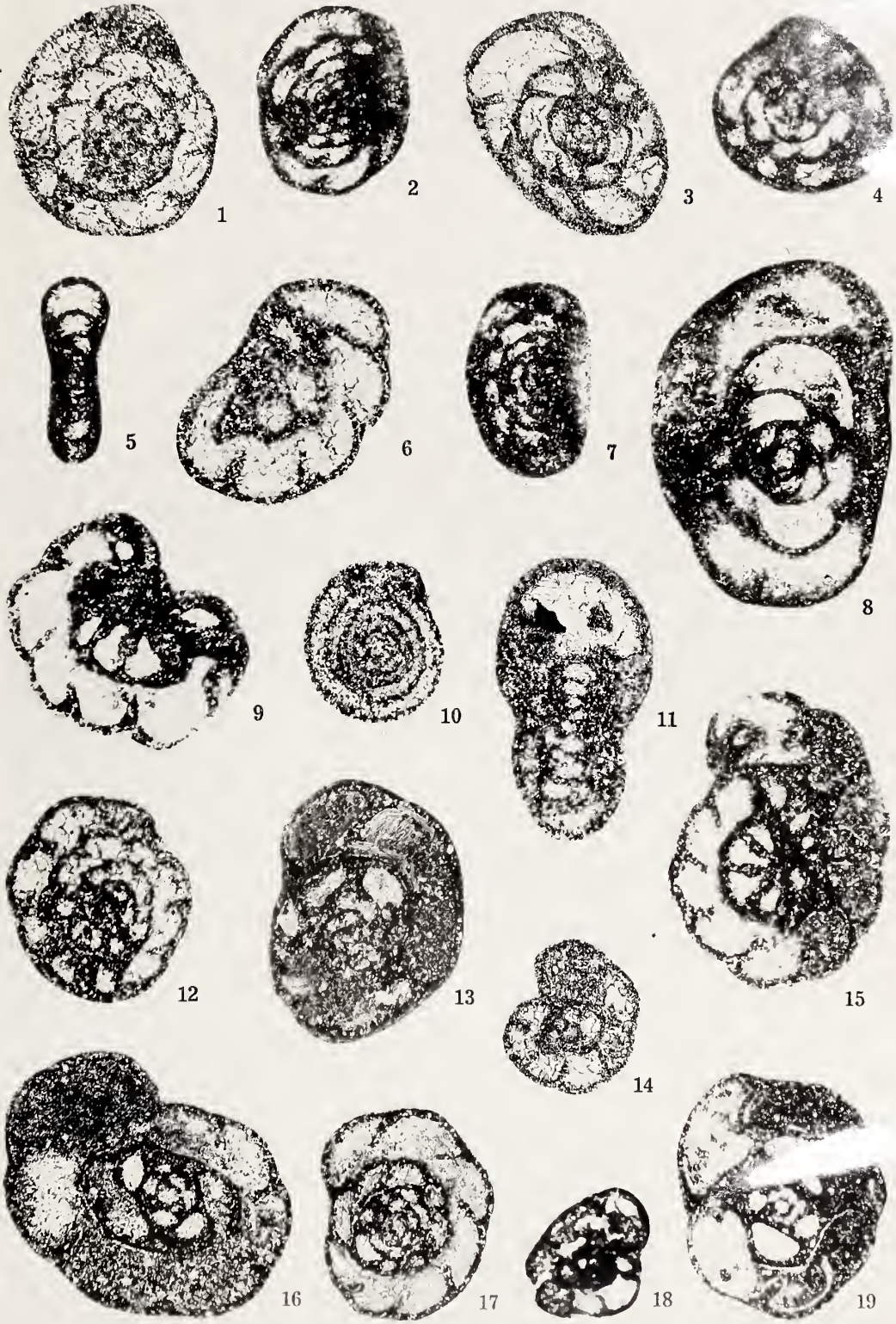

PLATE 6

EXPLANATION OF PLATE 7

(all figures X60 unless indicated otherwise)

Tunnel Mountain Section (con't.)

Middle Beds - Mount Head Formation

Figures 1, 3: Archaediscus sp.; axial sections, PF 0015, PF 0016, (X116).....(p. 40)

Figures 2, 6: Brunsia sp.; axial sections, PF 0005, PF 0006, (X116).....(p. 39)

Figures 4, 5: Tournayella? nonconstricta, n. sp.; 4, axial section, PF 0008; 5, sagittal section, PF 0009.....(p. 42)

Figure 7: Endothyra zelleri; sagittal section, PF 0047, (p. 53)

Figure 8: Endothyra sp.; axial section, PF 0048 (RG 57-1-30).

Figure 9: Ammodiscus sp. A; sagittal section, PF 0040 (p. 38)

Figures 10, 11, 16, 17: Plectogyra incrassata, n. sp.; 10, 16, oblique horizontal axial sections, PF 0102, PF 0103A; 11, horizontal axial section, PF 0103; 17, vertical axial section, PF 0104; 11 is the holotype.....(p. 67)

Figures 12, 13, 14: Endothyra zelleri; 12, axial section, PF 0051; 13, 14, sagittal sections, PF 0049, PF 0050.....(p. 53)

Figure 15: Endothyra robusta, n. sp.; axial section, PF 0172.....(p. 51)

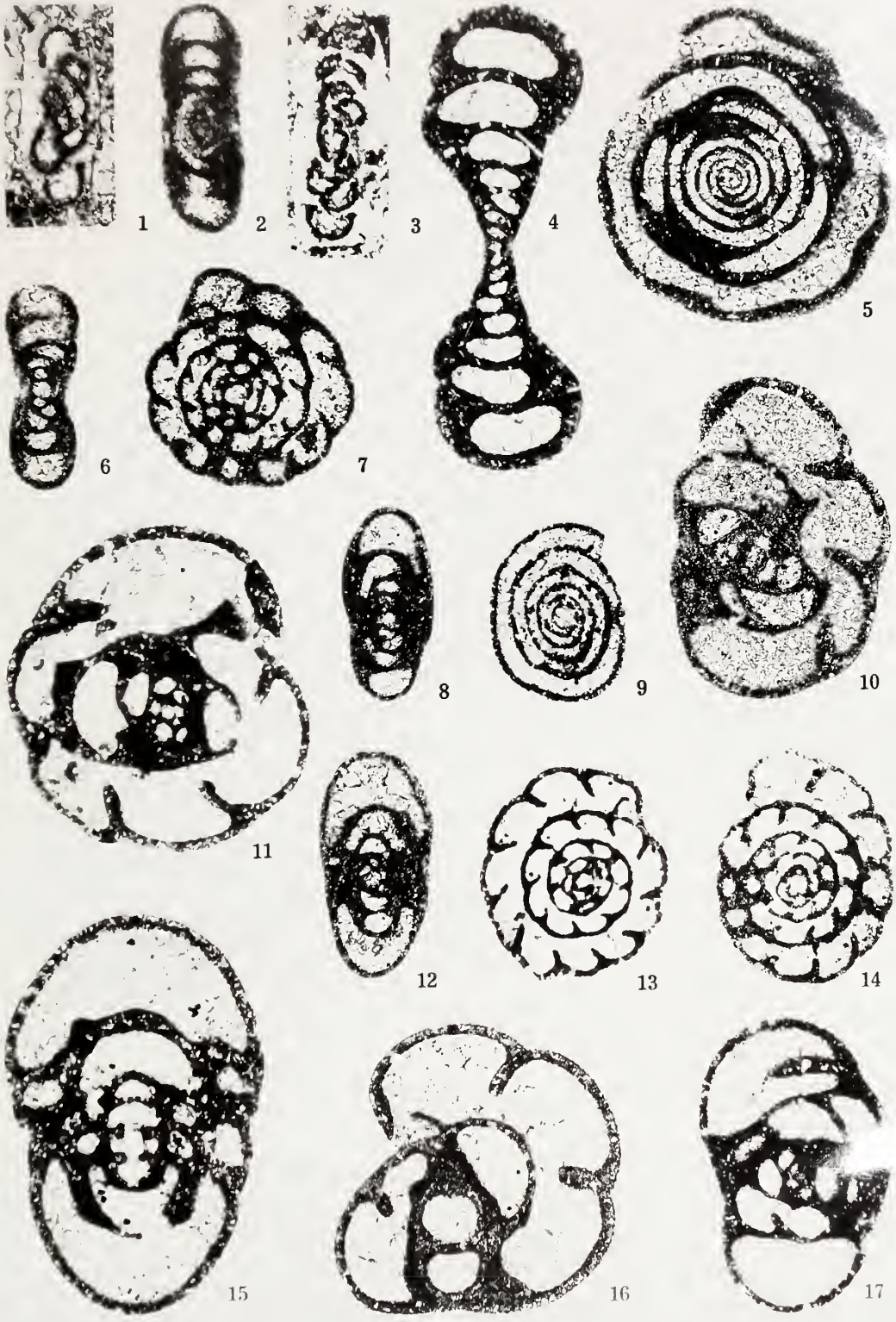

PLATE 7

EXPLANATION OF PLATE 8

(all figures X60 unless indicated otherwise)

Tunnel Mountain Section (con't.)

Middle Beds - Mount Head Formation

Figures 1, 4: Endothyra robusta, n. sp.; 1, sagittal section, PF 0173; 4, axial section, PF 0174; 1 is the holotype.....(p. 51)

Figure 2: Endothyra sp.; sagittal section, PF 0052 (RG 57-1-30)

Figure 3: Tournayella? nonconstricta, n. sp.; sagittal section, PF 0010.....(p. 42)

Figure 5: Plectogyra sp.; horizontal axial section, PF 0157 (RG 57-1-30).

Upper Beds - Mount Head Formation

Figure 6: Endothyra sp.; sagittal section, PF 0054 (RG 57-1-29).

Figure 7: Palaeotextularia sp.; longitudinal axial section (X90), PF 0022 (RG 57-1-29).

Figures 8, 12: Plectogyra arrecta, n. sp.; sagittal sections, PF 0041, PF 0042; 8 is the holotype...(p. 65)

Figure 9: Endothyra sp.; sagittal section, PF 0066 (RG 57-1-29).

Figure 10: Endothyra zelleri; sagittal section, PF 0053.....(p. 53)

Figure 11: Enlarged view of PF 0103A showing thin outer layer (tectum) and granular inner layer; inner tectorium is not clearly differentiated.

Figure 13: Plectogyra sp.; horizontal axial section, PF 0122 (RG 57-1-29).

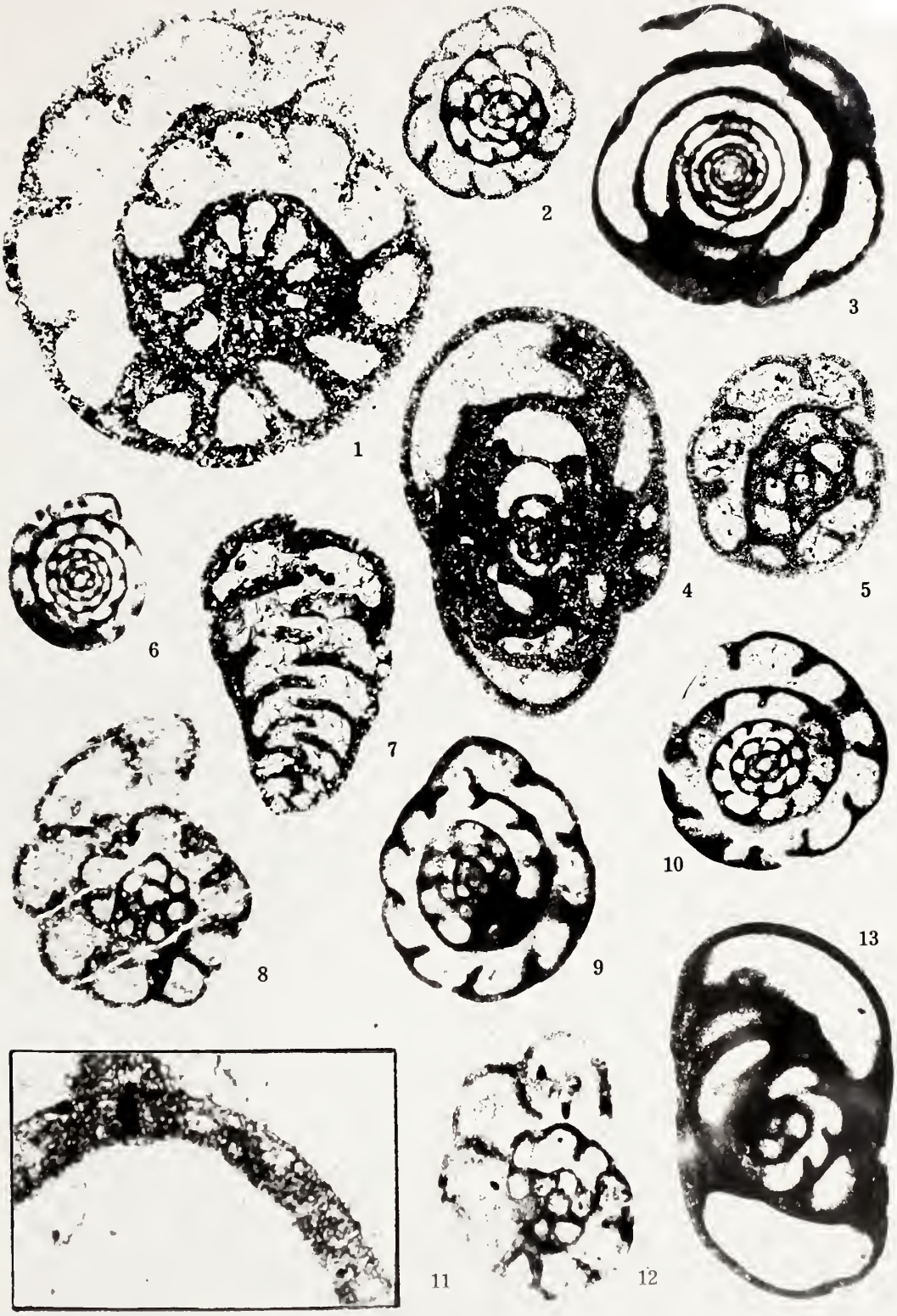

PLATE 8

EXPLANATION OF PLATE 9

(all figures X60 unless indicated otherwise)

Tunnel Mountain Section (con't.)

Upper Beds - Mount Head Formation

Figures 1, 12, 17: *Endothyra flatile*, n. sp.; sagittal sections, PF 0044, PF 0045, PF 0046; 12 is the holotype (p. 48)

Figures 2, 3, 4, 15, 20: *Eostaffella* sp. A; 2, 15, sagittal sections, PF 0080, PF 0077; 3, 4, 20, axial sections, PF 0078, PF 0079, PF 0081; (4, X90)...(p. 81)

Figures 6, 7 8: *Eostaffella* sp. B; horizontal axial sections, PF 0100, PF 0101, PF 0102; (6, X90)...(p. 82)

Figures 5, 10: *Plectogyra* sp. D; 5, horizontal axial section, PF 0160; 10, vertical axial section, PF 0161.....(p. 78)

Figures 9, 13: *Endothyra* sp. C; 9, sagittal section, PF 0067; 13, axial section, PF 0068.....(p. 56)

Figure 11: *Plectogyra arrecta*, n. sp.; sagittal section, PF 0043 .....(p. 65)

Figure 14: *Endothyra* sp.; sagittal section, PF 0069, (RG 57-1-20).

Figure 16: *Plectogyra* sp.; horizontal axial section, PF 0162 (RG 57-1-20).

Figure 18: *Endothyra* sp. D; sagittal section, PF 0070 (p. 57)

Figure 19: *Plectogyra* sp.; vertical axial section, PF 0073 (RG 57-1-20).

Figure 21: Enlarged view of PF 0070 showing long septal face and preceding short resorbed septa (X 190).

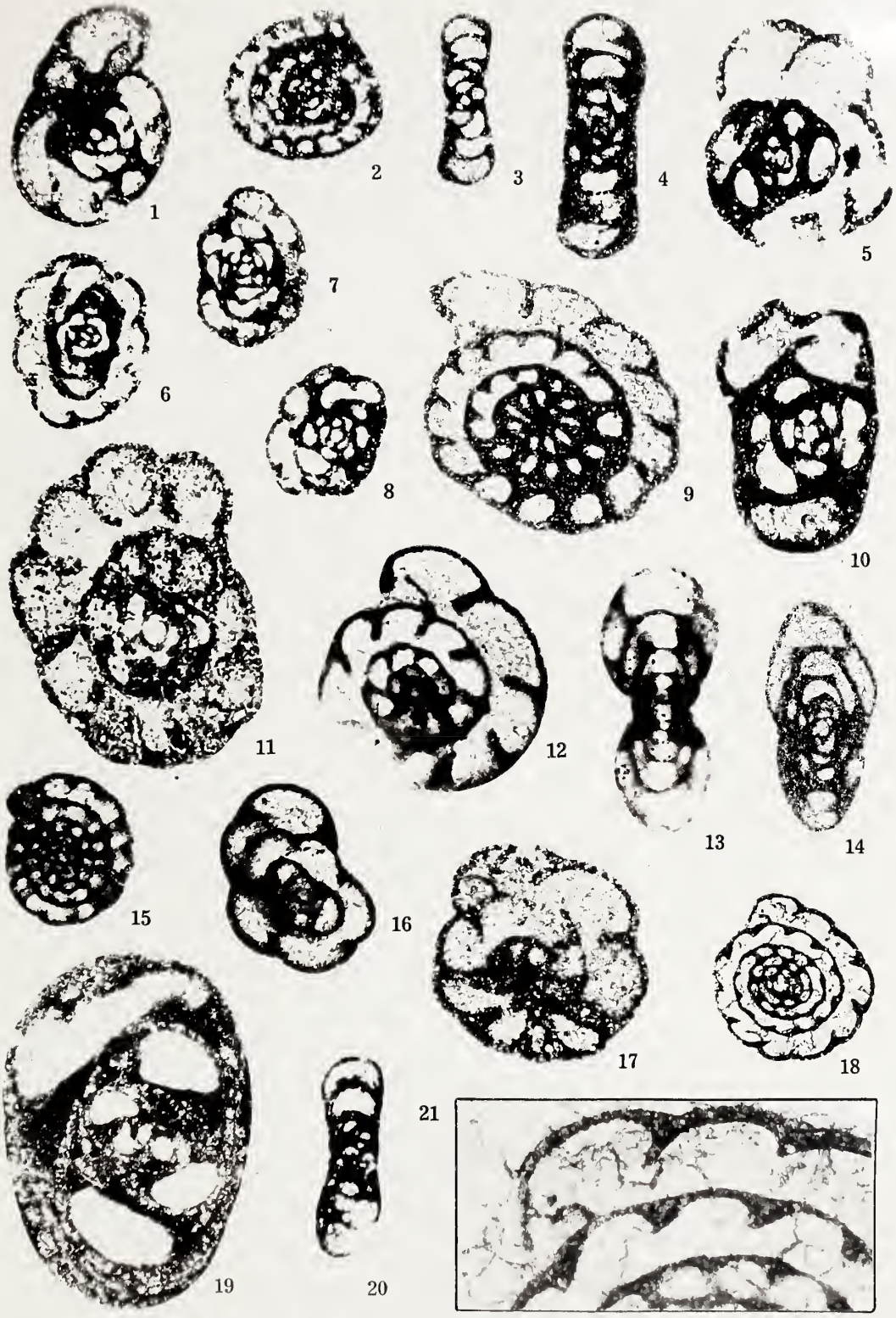

PLATE 9

EXPLANATION OF PLATE 10

(all figures X60 unless indicated otherwise)

Tunnel Mountain Section (con't.)

Upper Beds - Mount Head Formation

Figure 1: Endothyra robusta, n. sp.; sagittal section, PF 0176 ..... (p. 51)

Figure 2: Endothyra sp.; axial section, PF 0180 (RG 57-1-18).

Figure 3: Plectogyra sp. E; vertical axial section, PF 0178 ..... (p. 79)

Figures 4, 7: Plectogyra spp.; 4, oblique horizontal axial section, PF 0163; 7, horizontal axial section, PF 0177 (RG 57-1-18).

Figure 5: Permodiscus sp.; axial section, PF 0018 (X216) ..... (p. 41)

Figure 6: Palaeotextularia sp.; longitudinal axial section, PF 0023 (X90), (RG 57-1-18).

Figure 14: Enlarged view of PF 0178 showing the inner dark tectorium, middle light diaphanotheca, and outer dark tectum. Radial hyaline layer on outside of tectum is considered superficial.

Lower Beds - Etherington Formation

Figures 8, 9: Plectogyra kleina Woodland; oblique horizontal axial sections, PF 0164, PF 0165 (p. 69)

Crowsnest Ridge

Upper Beds - Mount Head Formation

Figure 10: Plectogyra sp.; oblique horizontal axial section, PF 0166.

Figures 11, 12: Endothyra spp.; 11, axial section, PF 0071; 12, sagittal section, PF 0072.

Figure 13: Endothyra robusta, n. sp.; oblique section PF 0179 .....(p. 51)

PLATE 10

EXPLANATION OF PLATE 11

(all figures X60 unless indicated otherwise)

Mount Rae Section

Lower Beds - Mount Head Formation

Figure 1: Endothyra sp.; axial section, PF 0159.

Interval 40-50' below top of Mount Head Formation

Figures 2, 6: Endothyra spp.; 2, axial section, PF 0180; 6, sagittal section, PF 0192.

Figure 3: Plectogyra sp.; horizontal axial section, PF 0171.

Figure 4: Tournayella? nonconstricta, n. sp.; axial section, PF 0007.....(p. 42)

Figures 5, 11: Archaediscus sp.; 5, axial section, PF 0014; 11, sagittal section, PF 0017 (X116).(p. 40)

Figures 7, 9, 10: Plectogyra incrassata, n. sp.; 9, 10, horizontal axial sections, PF 0184, PF 0185; 7, vertical axial section, PF 0187.....(p. 67)

Figure 8: Endothyra macra E. J. Zeller; sagittal section, PF 0086.....(p. 49)

Figures 12, 14: Endothyra robusta, n. sp.; 12, partial section of extremely large form (X74), PF 0182; axial section, PF 0183, 14..(p. 51)

Figure 13: Brunsia sp.; axial section, PF 0007 (X116) (p. 39)

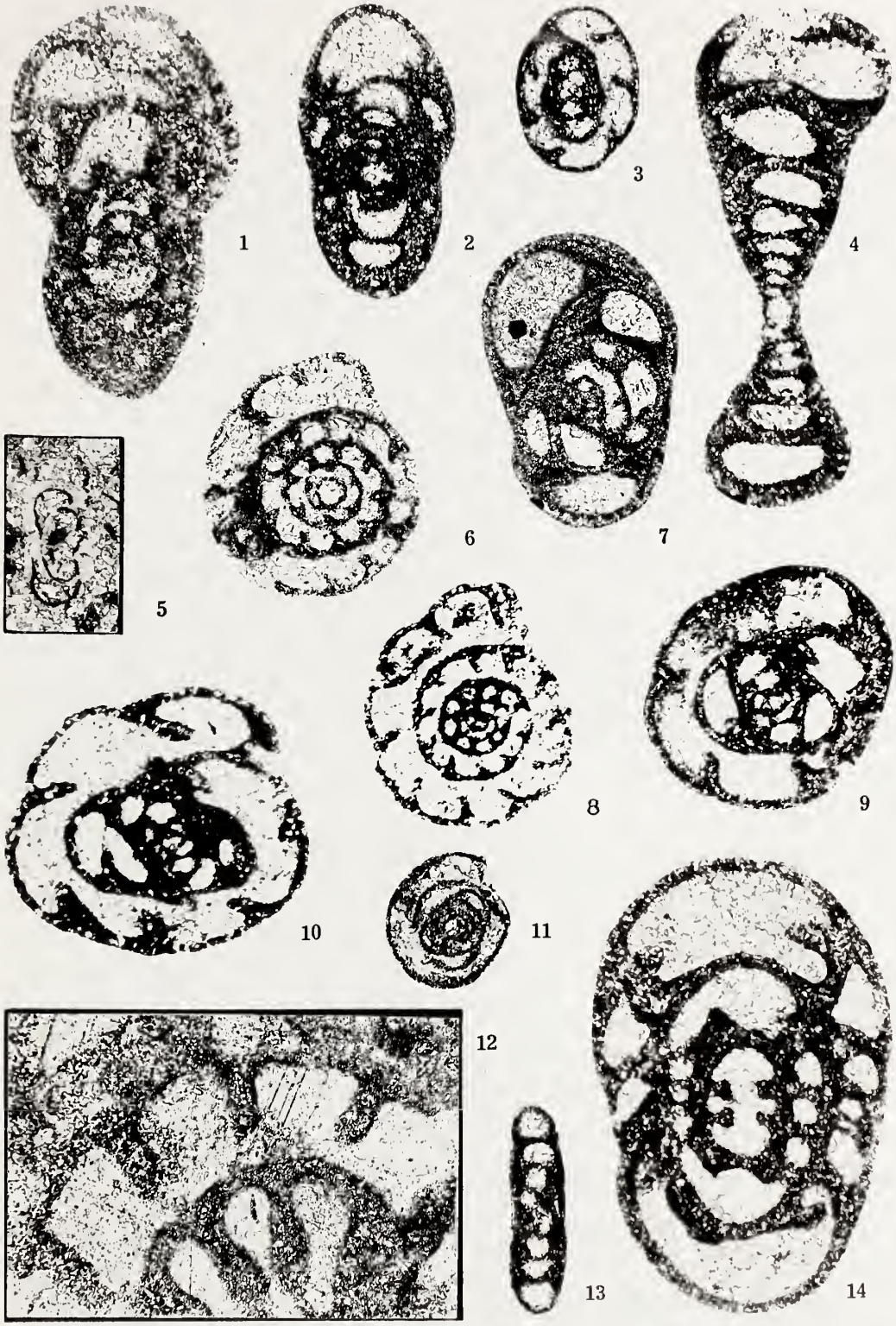

PLATE 11

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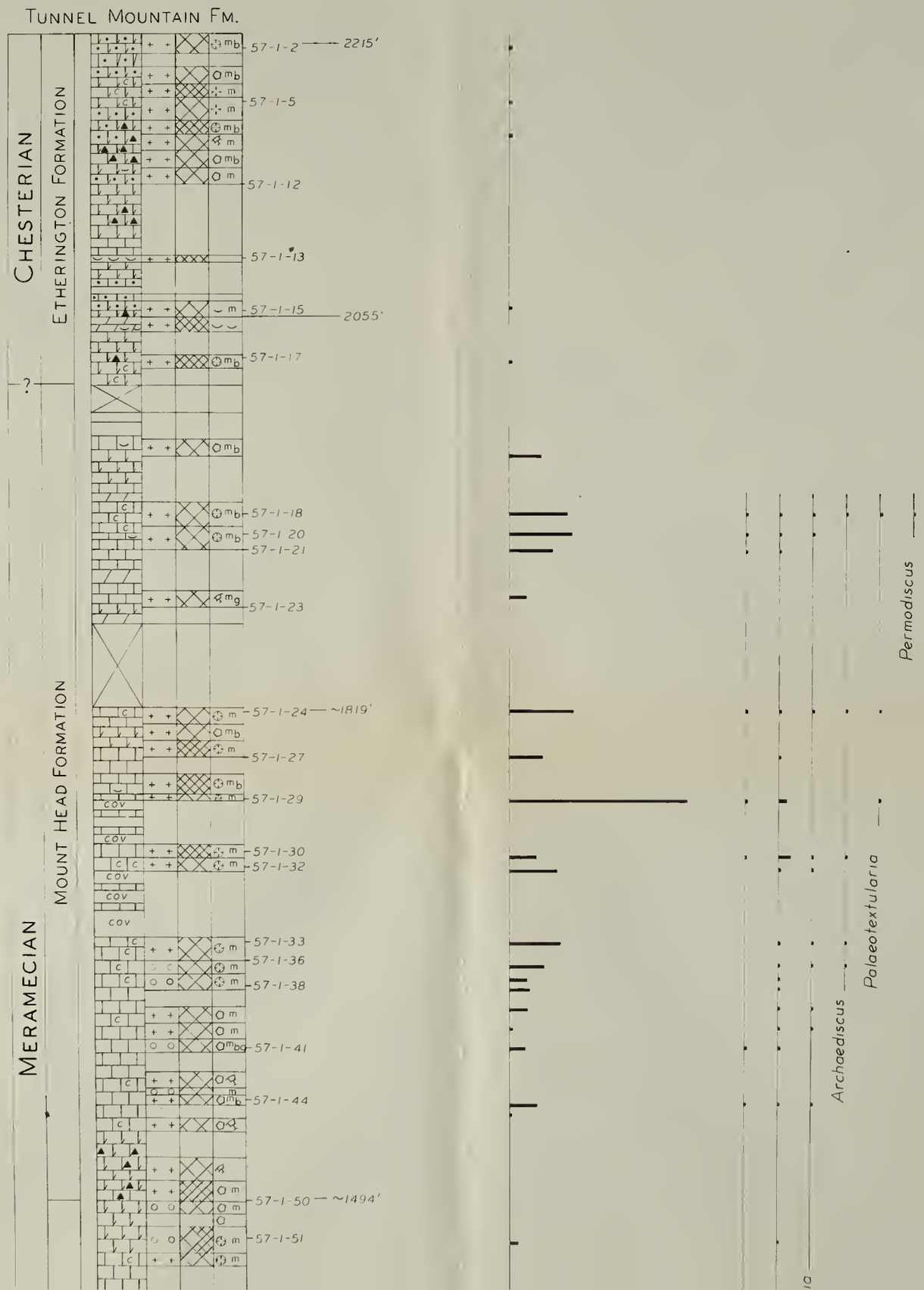
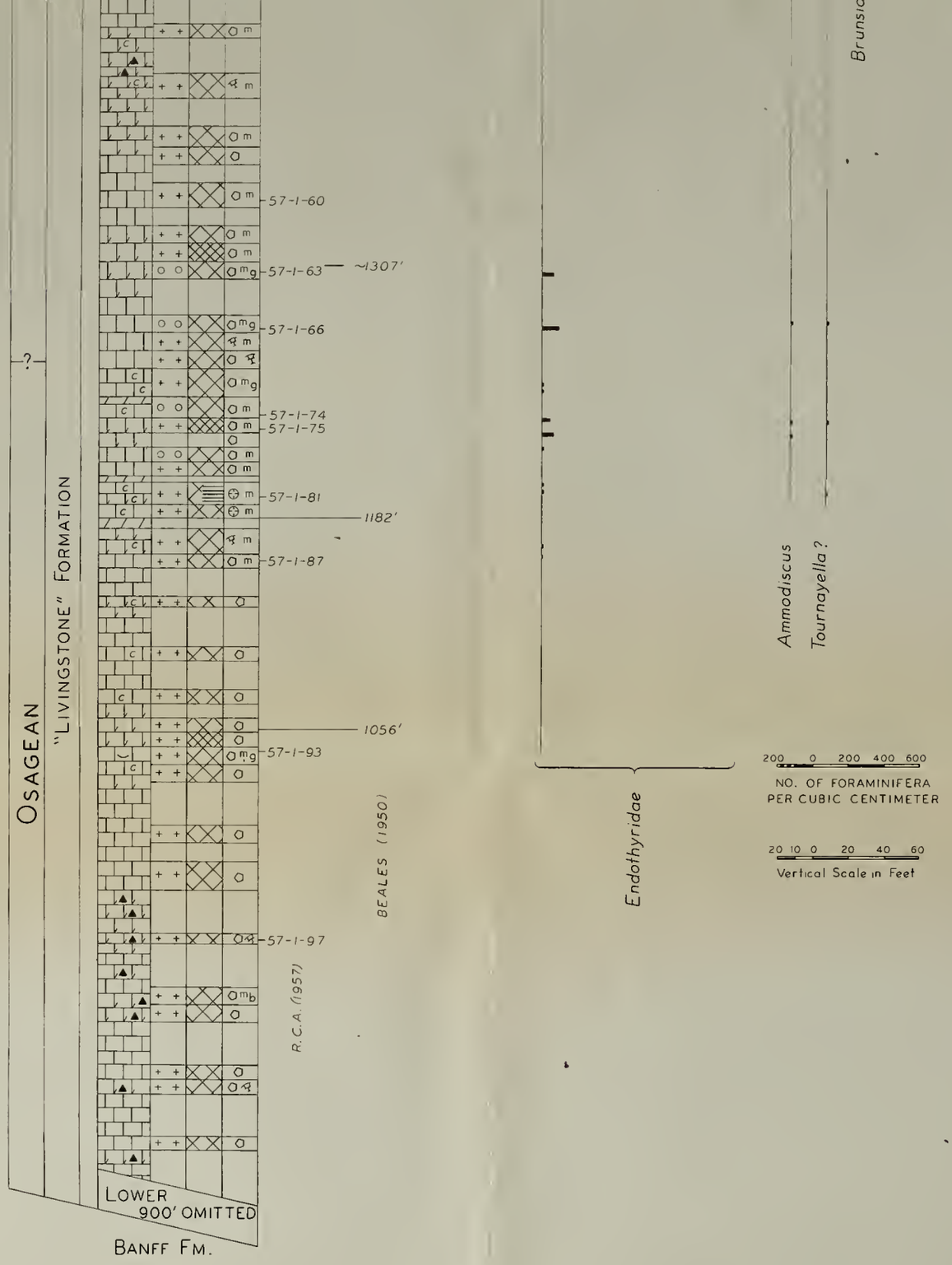
FIGURE 3
DISTRIBUTION AND RELATIVE ABUNDANCE OF MISSISSIPPIAN FORAMINIFERA IN THE CANADIAN ROCKIES

(A) TUNNEL MOUNTAIN SECTION





LEGEND

FIELD LITHOLOGY

- Calcareous shale
- Argillaceous limestone
- Limestone
- Limestone – <50% dolomitized
- Limestone – 50% dolomitized
- Dolomite
- Silty dolomite
- Silt
- Brecciated dolomite
- Anhydrite
- Chert
- Coral
- Brachiopod

MICROSCOPIC TEXTURAL ELEMENTS *

- Intraclasts (rock fragments)
- Allochemical Constituents: Bioclasts, Oolites, Pellets
- Micracrystalline calcite ooze – matrix
- Cement: Sparry calcite, grain size 10–40 μ; Sparry calcite, grain size >40 μ

ORGANIC REMAINS

- Crinoidal debris
- Bryozoa
- Coral
- Brachiopod
- Ostracod
- "Birdseye" type limestone

al algae

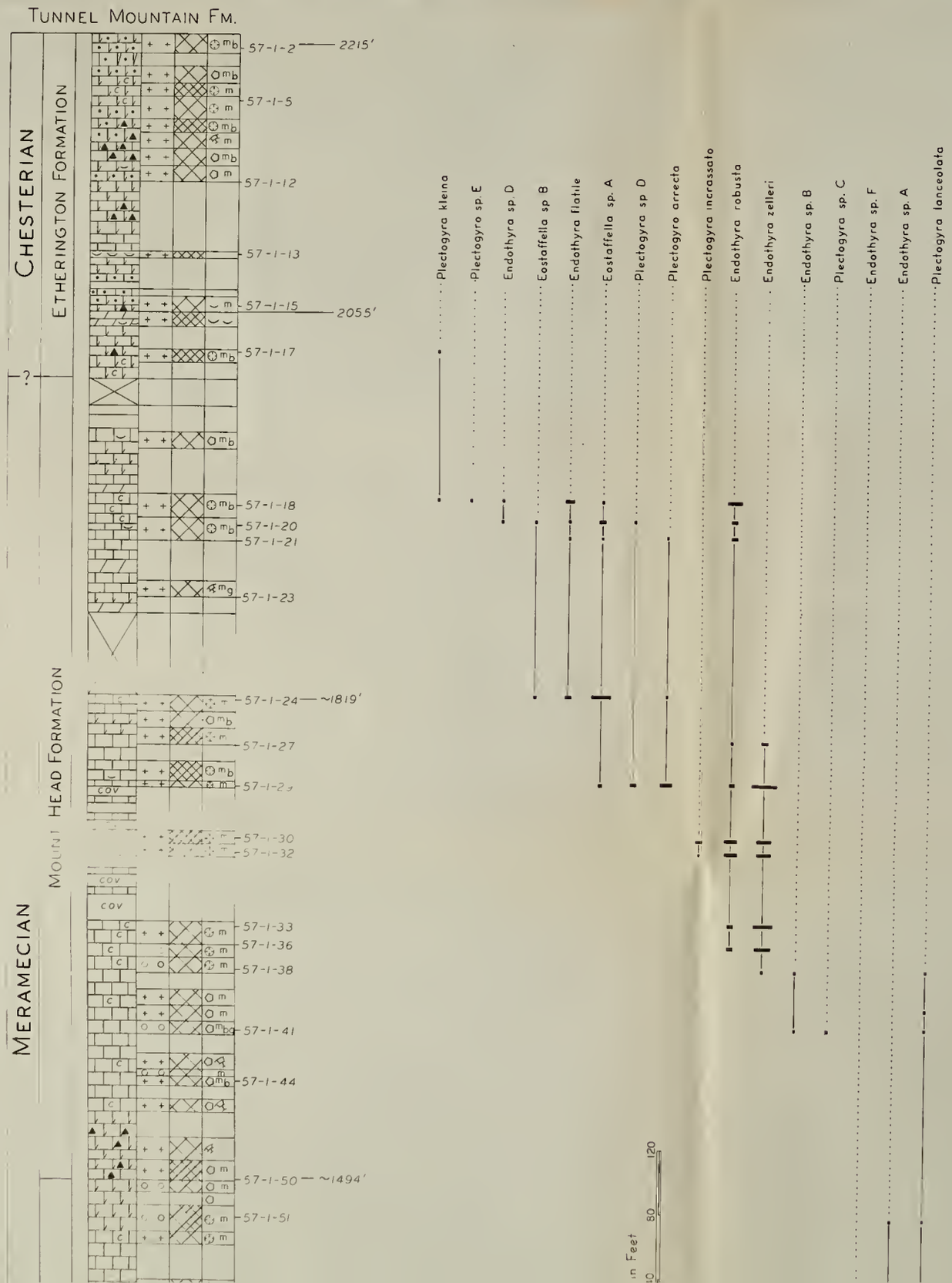
m minor elements incl. crinoidal debris and/or bryozoan, ostracods, foraminifera, brachiopods (b) and gastropods (g)

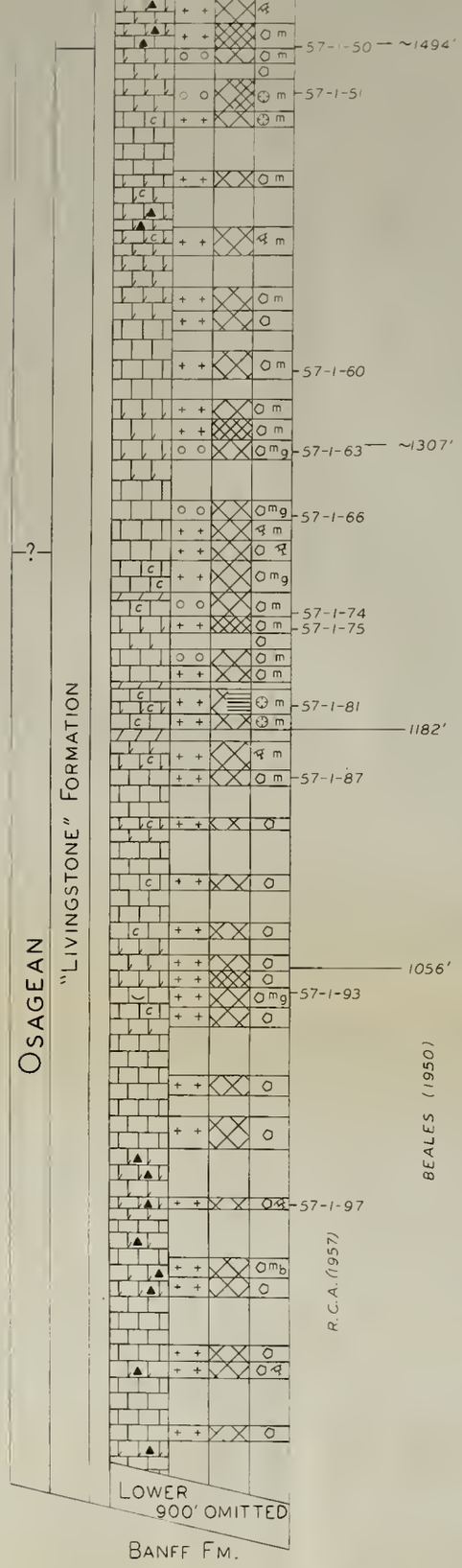
* Modified after Folk (1959)

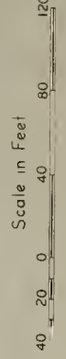
FIGURE 3a

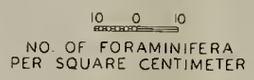
Distribution and Relative Abundance of Mississippian Foraminifera in the Canadian Rockies

(A) Tunnel Mountain Section





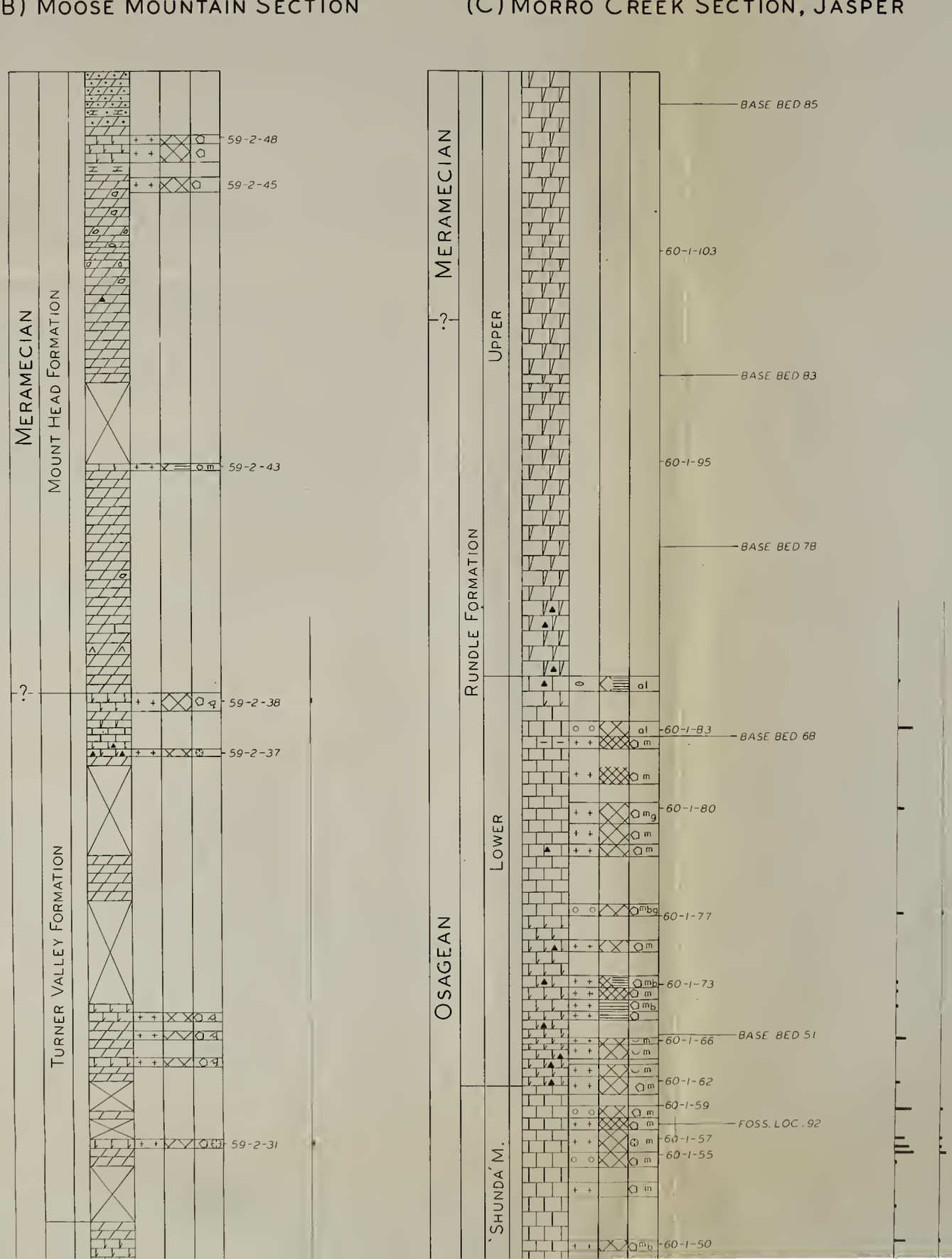


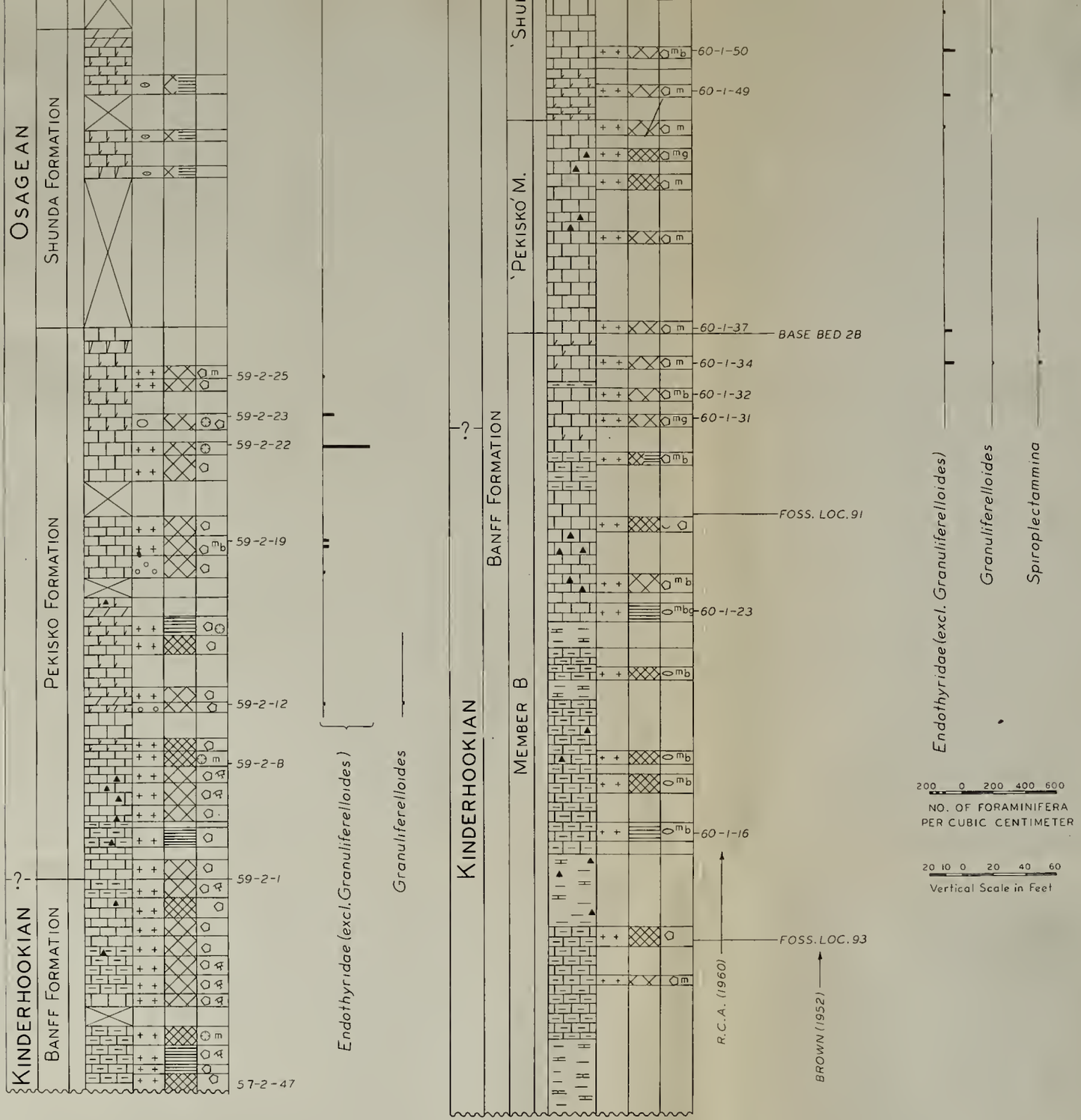


LEGEND

FIELD LITHOLOGY	MICROSCOPIC TEXTURAL ELEMENTS *
Calcareous shale	Intraclasts (rock fragments)
Argillaceous limestone	Bioclasts, Oolites, Pellets — Allochemical Constituents
Limestone	Microcrystalline calcite ooze – matrix
Limestone – <50% dolomitized	Sparry calcite, grain size 10–40 μ; Sparry calcite, grain size >40 μ — cement
Limestone – 50% dolomitized	**ORGANIC REMAINS**
Dolomite	Crinoidal debris; Bryozoa; Coral; Brachiopod; Ostracod; "Birdseye" type limestone
Silty dolomite	al algae
Silt	m minor elements incl. crinoidal debris and/or bryozoan, ostracods, foraminifera, brachiopods (b) and gastropods (g)
Brecciated dolomite	
Anhydrite	
Chert	
Coral	
Brachiopod	

FIGURE 4
DISTRIBUTION AND RELATIVE ABUNDANCE OF MISSISSIPPIAN FORAMINIFERA IN THE CANADIAN ROCKIES





LEGEND

FIELD LITHOLOGY	
	Calcareous shale
	Argillaceous limestone
	Limestone
	Limestone – <50% dolomitized
	Limestone – 50% dolomitized
	Dolomite
	Silty dolomite
	Silt
	Brecciated dolomite
	Anhydrite
	Chert
c	Corol
	Brachiopod

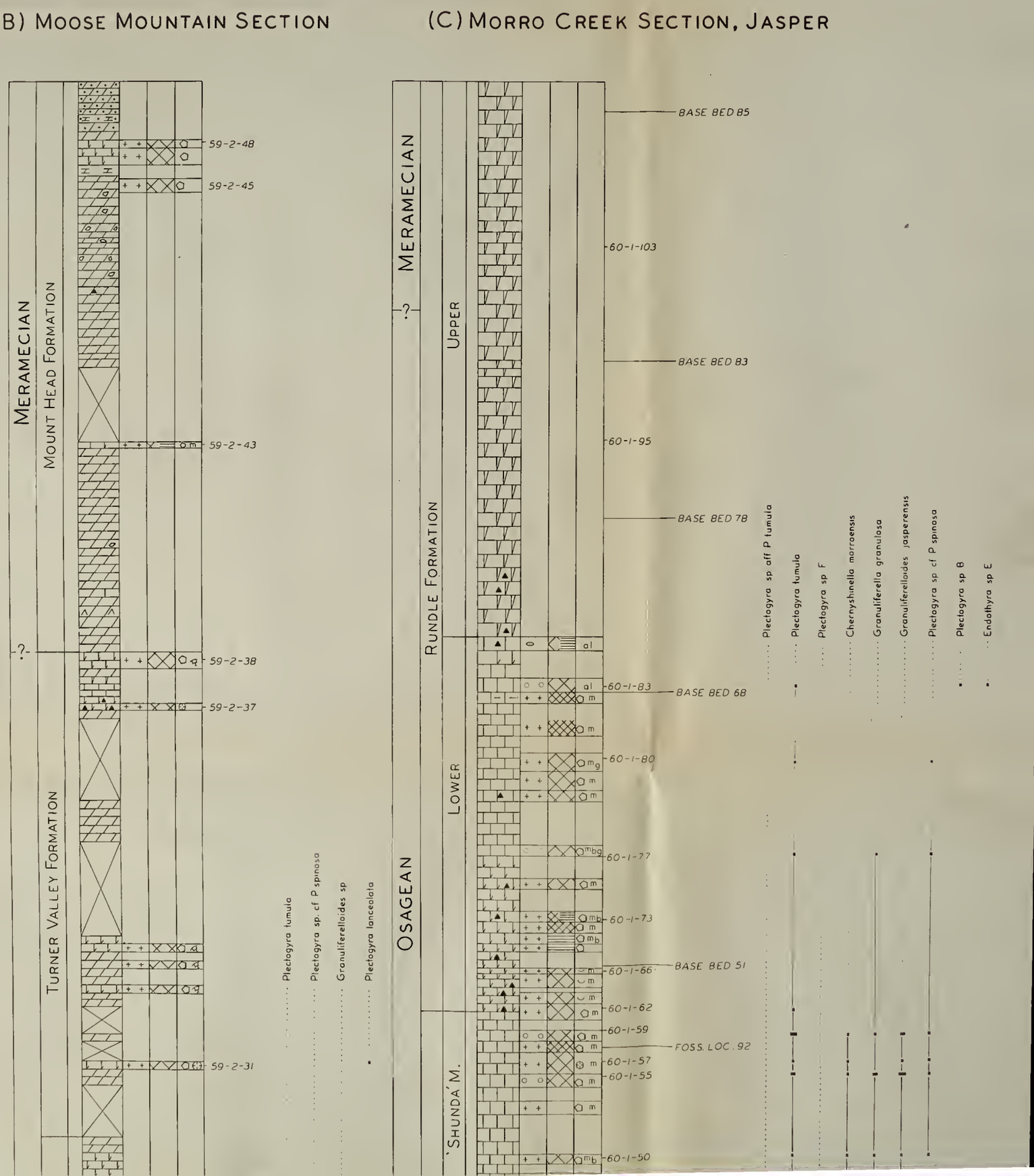
MICROSCOPIC TEXTURAL ELEMENTS *	
	Intraclasts (rock fragments)
	Bioclasts
	Oolites
	Pellets
	Allochemical Constituents
	Microcrystalline calcite ooze - matrix
	Sparry calcite, grain size 10-40 μ
	Sparry calcite, grain size >40 μ
	cement

ORGANIC REMAINS		
	Crinoidal debris	ol algae
	Bryozoa	m minor elements incl. crinoidal debris and/or bryozoan, ostracods, foraminifera, brachiopods (b) and gastropods (g)
	Corol	
	Brachiopod	
	Ostracod	
	"Birdseye" type limestone	

* Modified after Folk (1959)

FIGURE 4a

DISTRIBUTION AND RELATIVE ABUNDANCE OF MISSISSIPPIAN FORAMINIFERA IN THE CANADIAN ROCKIES



LEGEND

FIELD LITHOLOGY	MICROSCOPIC TEXTURAL ELEMENTS *
Calcareous shale	Intraclasts (rock fragments)
Argillaceous limestone	Bioclasts — Allochemical Consituents
Limestone	Oolites — Allochemical Consituents
Limestone – <50% dolomitized	Pellets — Allochemical Consituents
Limestone – 50% dolomitized	Microcrystalline calcite ooze - matrix
Dolomite	Sparry calcite, grain size 10-40 μ — cement
Silty dolomite	Sparry calcite, grain size >40 μ — cement
Silt	**ORGANIC REMAINS**
Brecciated dolomite	Crinoidal debris — al algae
Anhydrite	Bryozoa — m minor elements incl. crinoidal debris and/or bryozoan, ostracods, foraminifera, brachiopods (b) and gastropods (g)
Chert	Coral
Coral	Brachiopod
Brachiopod	Ostracod
	"Birdseye" type limestone

* Modified after Folk (1959)

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